



Figure 34. View to the southeast of the principal access road that ascends the incised, east sloping piedmont alluvial fan surface (Qfo). A linear, two-track road visible on the left side of the photograph is a power-line road. Also visible in the photo are prominent berms constructed along the edges of the tailings (At).



Figure 35. View west from the access road toward the U16a Tunnel portal. In the middle of the photograph the rilled and gullied tailings slope (Ast) is visible. Debris and tailings are visible in the stream along the base of the tailings slope.

term effect is a locally over steepened valley floor, which can lead to future incision and the erosion and transport of large volumes of sediment to downstream reaches.

Some roads were situated in narrow bedrock valleys and likely required little preparation (e.g., the road to the explosives magazine; Figure 36). Because of the thickness of the alluvium currently in the narrow valley it is not possible to determine if road preparation was carried out. Where road construction occurred, much of the native vegetation was destroyed. Since abandonment of U16a Tunnel, grasses, sage and rabbit brush have re-established along the margins of roads, and on the tailings pile and slopes in the intervening decades since the last tunneling activities were undertaken.

Cut Slopes

Cut slopes (Asc) were made principally during road construction and maintenance activities, during excavations for buildings and equipment staging and storage area in and around U16a Tunnel portal. For example, a prominent cut slope associated with a road on Shoshone Mountain near Tippihah Point is visible as one approaches U16a Tunnel and from the U16a Tunnel portal area (Figure 37). Cut slopes are commonly associated with small colluvial wedges of loose rock and soil shed from the cut slope. In some cases small alluvial and colluvial fans have spread across roads and staging areas.

Cut slopes may be many meters tall where road alignment and topography require substantial slope excavation, and where removal or redistribution of large volumes of friable bedrock and colluvium may have been required. Material excavated from cut slopes in the U16a Tunnel area was commonly used elsewhere in road construction, especially to fill low areas or to raise the elevation of the road bed. In the U16a Tunnel area, cut slopes are generally less than 2 m (6.6 ft) high and occupy about 1.2 hectares (3 acres). Near the U16a Tunnel portal, bedrock cut slopes are as much as 7.5 to 10.5 m (25 to 35 ft) high but are relatively stable. In some places near the portals, protective mesh was installed to reduce the hazard of rock fall (Figures 33, 35, and 37). Cut slopes in colluvium are generally steep, unvegetated, and readily shed material onto roads, fill areas, and natural slopes. Where access roads are cut into slopes, there is now a tendency for sediment to accumulate in roadside ditches thereby restricting drainage, causing runoff to flow across the roadbed and form rills and gullies on the road bed and adjacent slopes.

Artificial Fill

Artificial fill (Af) deposits cover an area of about 1 acre (0.4 hectares). Given the potential thicknesses of fills (0.3 to 4.5 m or more; 1 to 15 ft), fill may constitute large volumes of material. In terms of geomorphic process, artificial fill represents temporary sediment storage that may be eroded many years later. Many of the flat areas of artificial fill are vegetated with grasses and low shrubs (Figures 32 and 33).

Artificial fill is commonly placed by bulldozing or dumping material derived from cut slopes into a topographic low and continuing to fill the depression until the surface is built to a desired level, or by the same process but engineered by careful selection of material size and composition, adequate mixing, and compaction in specific layers (i.e., lifts).

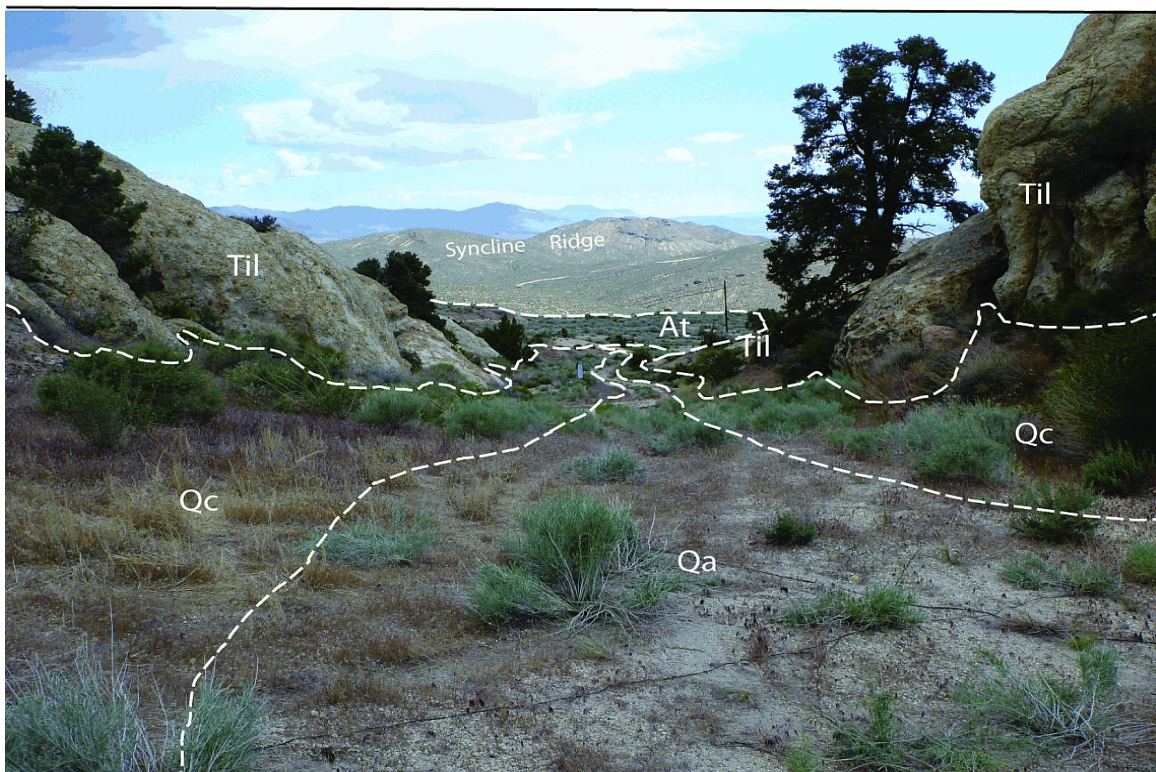


Figure 36. Photographs to the northeast of small drainage at the south end of the U16a Tunnel portal area. The drainage was used as a road to access the explosives magazine (top) and has been covered with alluvium (Qa), colluvium (Qc) derived from bedrock (Til) and colluvial slopes, and fill material used to improve and maintain the road.

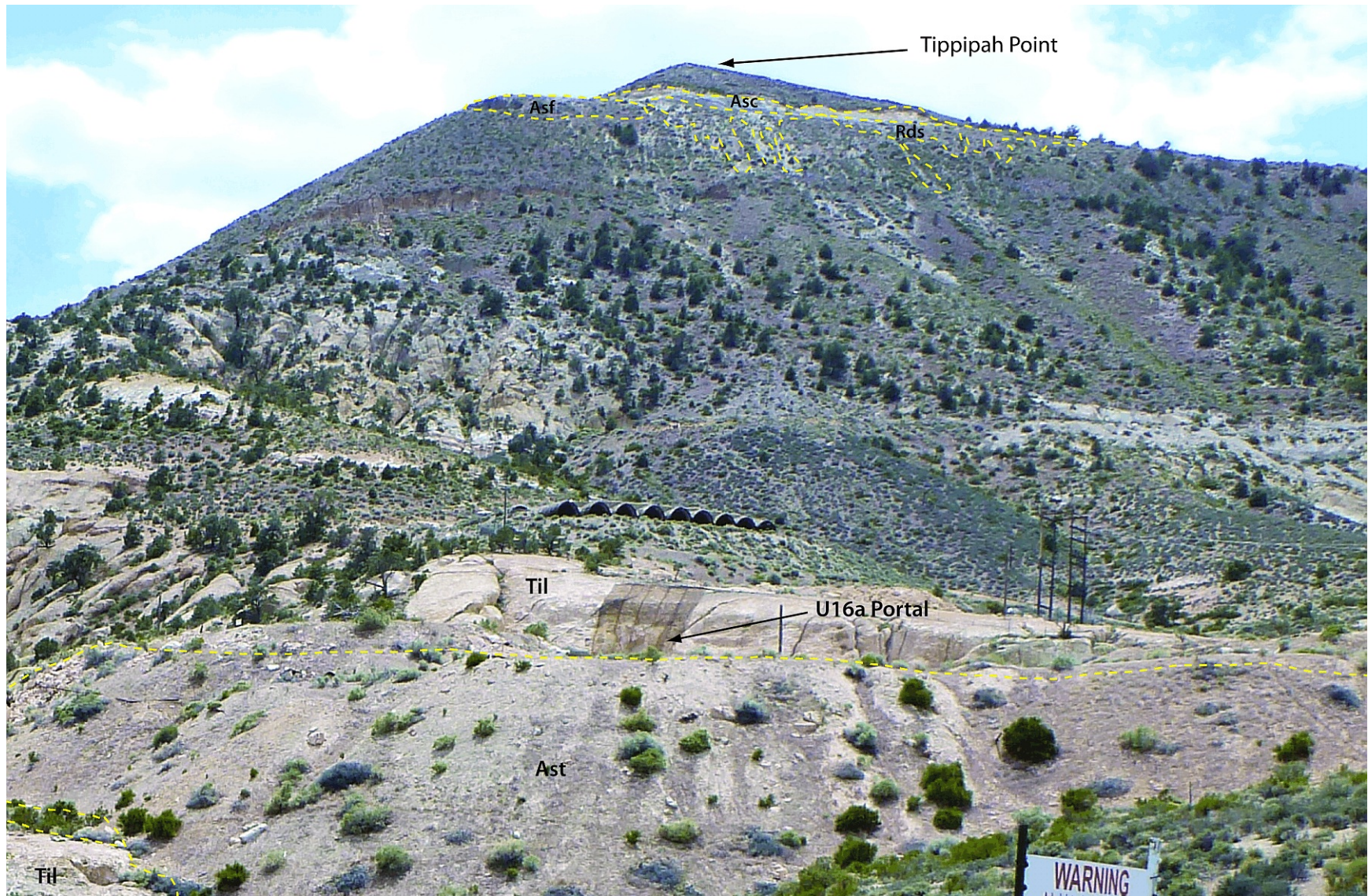


Figure 37. View to the west toward the U16a Tunnel portal and Shoshone Mountain from the access road. The prominent rilled and gullied tailings slope is visible in the foreground. A prominent road cut (Asc) in bedrock below Tippipah Point is visible just below the skyline. Large amounts of road side cast (Rds) material have spilled down the side of Shoshone Mountain impinging on the vegetation.

Buildings and major road construction normally require engineered fill to meet established construction codes. However, it is not known if the artificial fill in the U16a Tunnel portal area and on Shoshone Mountain was engineered or simply dumped on the existing surface and graded. Because there is no obvious cracking of concrete pads, or displacements of the fills after nearly 40 years, it is probable that some form of mechanical fill was used in meeting construction norms.

Road Side Cast

Road side cast (Rds) consists of road bed material that is pushed to the side of roads during grading as part of roadbed leveling and smoothing. Quite commonly, material is unavoidably pushed over the edge of steep slopes where it may be transported long distances down slope. The slope angle, material size and composition, and amount of material govern the distance of down slope movement and subsequent impact on the slope system and drainages at the toes of the slopes. For the purposes of this report, the road side cast also includes fill material that is draped over hill slopes as a result of the process of creating fill areas such as road turnouts and staging areas.

In the study area, the road side cast covers about 7 hectares (17 acres). Road side cast is most notable on the slopes immediately west of the U16a Tunnel portal and on the east-facing slope of Shoshone Mountain adjacent to Tippihah Point. The slopes adjacent to the road are very steep (> 70 percent slope) and a substantial amount of material was displaced during the cutting and filling when extending the road to the mountain top. Although difficult to determine without extensive field investigation, a visual inspection suggests that the most significant amounts of road side-cast material extend less than 10 m from the roadbed, although the road side-cast east of Tippihah Point extends more than 100 m downslope (Figure 37). The greatest impact from the perspective of modification to the landscape is generally confined to the area within a few meters of the road bed edge.

Mining Activities and Mine Tailings

Site excavation activities, primarily mining and the emplacement of fill for the preparation of building sites and staging areas, produced both large and small but recognizable modification of the natural landscape. Mining activities associated with development of the U16a Tunnel complex are responsible for the dumping of tailings in front of the tunnel portal and construction of prominent tailings slopes. The need to terrace tailings in the portal area attests to the large volume of material placed in the valley and adjacent slopes in the tributary drainages. The net effect of much of the activity related to development of the U16a Tunnel is that large volumes of crushed, easily erodible material was made available for transport to streams that drain to Yucca Flat. The potential detrimental effect of mine tailings (muck piles) because of their physical and chemical properties is discussed in various environmental assessments of tunnels and mines at NNSS (e.g., Defense Threat Reduction Agency, 2007; DOE, 2011).

Mine tailings (At) consist of material mined during tunnel construction. In the progress of typical mining operations, the muck removed following drilling and blasting is dumped at or near the tunnel portal. As additional material is removed, a broad, level area is developed to accommodate necessary construction-related activities, buildings, equipment storage, and staging areas. Excess muck is pushed over the edge where it may travel down slope until the angle of repose is attained. There is

no doubt that during initial tunnel development a certain volume of material was dumped directly onto the slopes adjacent to the portal area, but as the U16a Tunnel system became more extensive it was necessary to employ an efficient system to distribute tailings in a systematic manner. At U16a Tunnel, a relatively simple system was designed to transport muck by rail from the tunnel workings to a dumping station (Figure 32) where mobile earth moving equipment redistributed the muck on the tailing pile.

The tailings, including buildings and roads situated on the tailings constitute the largest area of disturbance, covering approximately 0.8 hectares (5 acres), and have filled a portion of the upper parts of the tributary drainages where the natural terrain abruptly steepens. The existing prism of muck is about 100 m (350 ft) long and 120 m (400 ft) wide. The greatest vertical thickness may be about 18 to 25 m (60 to 80 ft) at the southeastern end of the tailing pile and tapers to a few feet on the west near the portal and on the north and south ends where bedrock outcrops or is very near to the surface. Using a conservative estimate of average thickness of 4.6 m (15 ft), the volume of tailings disposed at the site may be upwards of several hundred thousand cubic feet.

Berms (Ab) have been pushed up along the edge of the tailings (Figures 32-34), likely in an effort to reduce the amount of surface runoff from the portal area and reduce the severity of gully activity on the tailings slopes. Tailings are visible in the tributary drainages.

Small drainage networks have developed on the tailings and tailings slopes (Figures 23, 35, and 37) and provide an effective transport linkage between potentially hazardous tailings and the downstream geomorphic and hydrologic systems. Rilled and eroded tailings occur on relatively unvegetated tailings slopes (Ast) and are characterized by visible dendritic networks of rills, parallel rills, and large, incised gullies. Approximately 1.3 hectares (3.3 acres) of unvegetated tailings slopes (Ast) are present on the margins of the tailings area.

Gullied tailings can be prominent sites of intense vertical and lateral erosion of the tailings slope (Figures 2, 14, and 16). Gullied tailings occur on unvegetated portions of the tailings slope and may be up to several feet deep and wide (0.6 to 1.2 m; 2 to 4 ft). The expansion of individual gullies commonly occurs by fluvial erosional processes, but localized slope failure of banks, localized debris flow, and sapping processes can also occur and introduce tailings into stream systems. Many of the gullies appear to be temporarily stabilized by vegetation that took hold following initial gully development.

SUMMARY: LANDSCAPE CHANGES AS RESULT OF TUNNEL ACTIVITIES AND IMPLICATIONS FOR GEOMORPHIC PROCESSES

At the U16a Tunnel, modification to the landscape have resulted from three principal activities: (1) road construction that cut through bedrock and colluvial mantled slopes to create an access road to the U16a Tunnel and the top of Shoshone Mountain and related road maintenance operations, (2) site preparation for activities related to experiments and testing in the U16a Tunnel complex and on Shoshone Mountain, and (3) mining activities related to development of the U16a Tunnel.

Road construction resulted in the cutting of bedrock and colluvial slopes to create access roads to and around the U16a Tunnel site and on the top of Shoshone Mountain in the area of Tippipah Point.

On the steeper sections of the small access road above the portal area excavating and scraping bedrock was most prevalent and resulted in perceptible changes in bedrock outcrop morphology. On the top of Shoshone Mountain, just below Tippihah Point it is apparent that substantial volumes of bedrock material were dislodged to make a narrow road, either by blasting or ripping the bedrock. Material side cast from the roads and fill piles typically is restricted to a narrow corridor along the road, but in some cases the material may have moved long distances down slope impinging on vegetation and altering local surface drainage and hydrology.

Site preparation activities, primarily the placing of fill for the preparation of building sites and staging areas, has resulted in small but recognizable modifications of the natural landscape. The net effect of much of the activity related to development of the U16a Tunnel complex is that large volumes of fresh, erodible material has been made available for transport to the main stem of the tributaries and eventually to larger systems that drain to Yucca Flat and to Frenchman Flat via Mid Valley and Barren Wash. On the top of Shoshone Mountain at Tippihah Point, road building activities, preparation of drill pads, and equipment sites resulted in the general redistribution of surficial deposits, and some bedrock quarrying. Substantial amounts of fill were placed across deep, narrow, stream valleys to accommodate the road.

Mining activities associated with development of the U16a Tunnel complex are responsible for the accumulation of tailings immediately at the portal of the tunnel and construction of the prominent muck piles. The terraced tailings in the vicinity of the U16a Tunnel portal attest to the large volume of material placed in stream valleys. The tailings locally may be up to 18 m (60 ft) thick at the east end of the tailings directly above former stream valleys. Rills and gullies have developed on the tailings pile and have been transporting fine grained tailings to the main branch of the two tributaries, at the north and south margins of the U16a Tunnel portal area.

DESCRIPTION OF U16a TUNNEL CULTURAL FEATURES

The project area for the U16a Tunnel consists of a discontinuous area on the northeast slope near the base and on top of Shoshone Mountain (Figure 2). Cultural features associated with mining the tunnel, testing nuclear and high explosives devices, a vent hole, and drill holes were recorded in the area near the U16a Tunnel portal and on the top of Shoshone Mountain near Tippihah Point. These two areas are separated approximately 1,000 m (3,280 ft) horizontally and 366 m (1,200 ft) vertically. Access to the U16a Tunnel Portal is by an access road that intersects with Mid Valley Road. At the end of the access road near the portal is a locked gate. Access to the drill holes on Shoshone Mountain is via the 16-04 road and access to the vent hole is by Mid Valley Road and an unnumbered road.

The U16a Tunnel Portal is along the west edge of a dirt and gravel pad used as a staging area for construction of the U16a Tunnel and testing activities within the tunnel (Figures 38). A covered trailer park, electrical equipment, and explosives storage area are on smaller dirt pads and across the general area adjacent to the Portal. This Portal area is generally circular in shape with a sinuous boundary (Figure 39). It is at an elevation of 1,649 m (5,410 ft) and is 330 m (1,082 ft) north-south by 364 m (1,195 ft) east-west encompassing 19.2 acres (7.8 hectares). The west edge abuts the steep slope of Shoshone Mountain and the east edge slopes abruptly into a drainage system. A muck pit is east of the Portal along the edge of the dirt pad but is in a restricted area and was not recorded as a feature during this investigation. A total of forty-seven features were recorded (Table 6), 41 at the Portal area and six on the top of Shoshone Mountain. Features at the Portal area are concrete foundations for buildings, rail lines, electrical supply and construction equipment, explosives storage, and a covered instrument trailer park. Five drill holes and one vent hole are near the top of Shoshone Mountain and on dirt pads generally less than 60 x 60 m (200 x 200 ft) (Figure 40 - Table 6). Visually, the most prominent feature at a drill hole is a vertical pipe that varies in diameter and height. Signs and stanchions are sometimes associated with the pipe. Ventilation equipment was found at the vent hole.

FEATURE DESCRIPTIONS

A description of the 47 features associated with the U16a Tunnel follows. Coordinates for the cultural features are listed in Table 1. Locational information is Universal Transverse Mercator coordinate system NAD 27, Zone 11. Features 1-41 were recorded at the Portal area and features 42-47 were recorded on top and upper slopes of Shoshone Mountain. All of the features on the dirt pad near the Portal are at an elevation of 1,649 m. Elevations for the remaining features vary and are given in the feature description.

Feature 1

Feature 1 is the U16a Tunnel Portal at UTM coordinate 571683 E, 4096300 N (Figures 39 and 41). The portal has been excavated into the northeast-facing exposure of tuff on the slope of Shoshone Mountain at an elevation of 1,649 m (5,410 ft). Visually, the opening is arched (Figure 41) and measures 4.57 m (15 ft) in width and 3.96 (13 ft) in height (at plug). Approximately 7.62 m (25 ft) within the tunnel is a concrete plug that seals the tunnel. The plug is dated August 12, 2008. The portal from the concrete plug to the rock face contains no sets or lagging to support the tunnel. Rock



Figure 38. Panoramic views of U16a Portal area, top view southwest, bottom view northwest (2011).

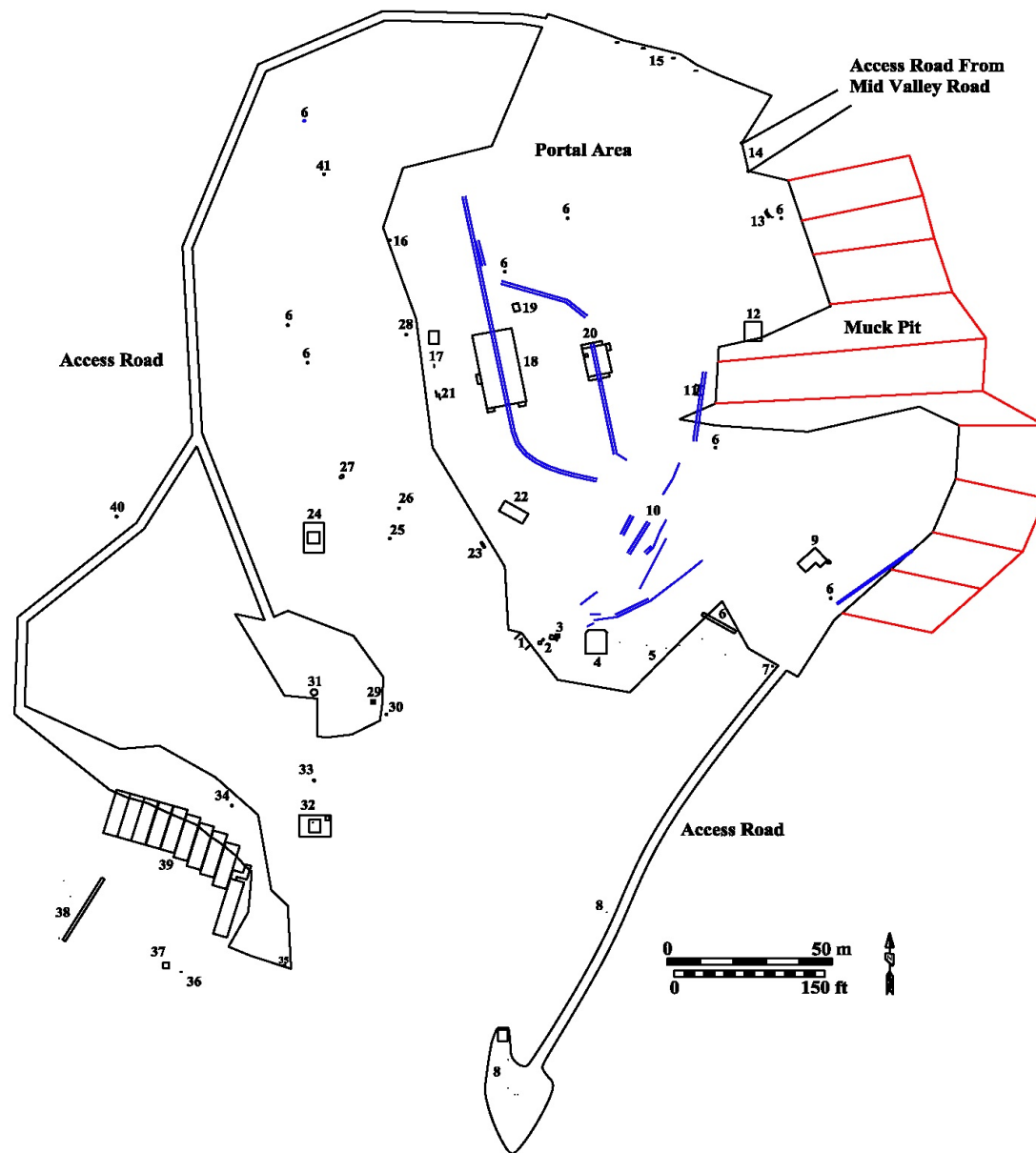


Figure 39. Location map of the U16a Portal area.
100

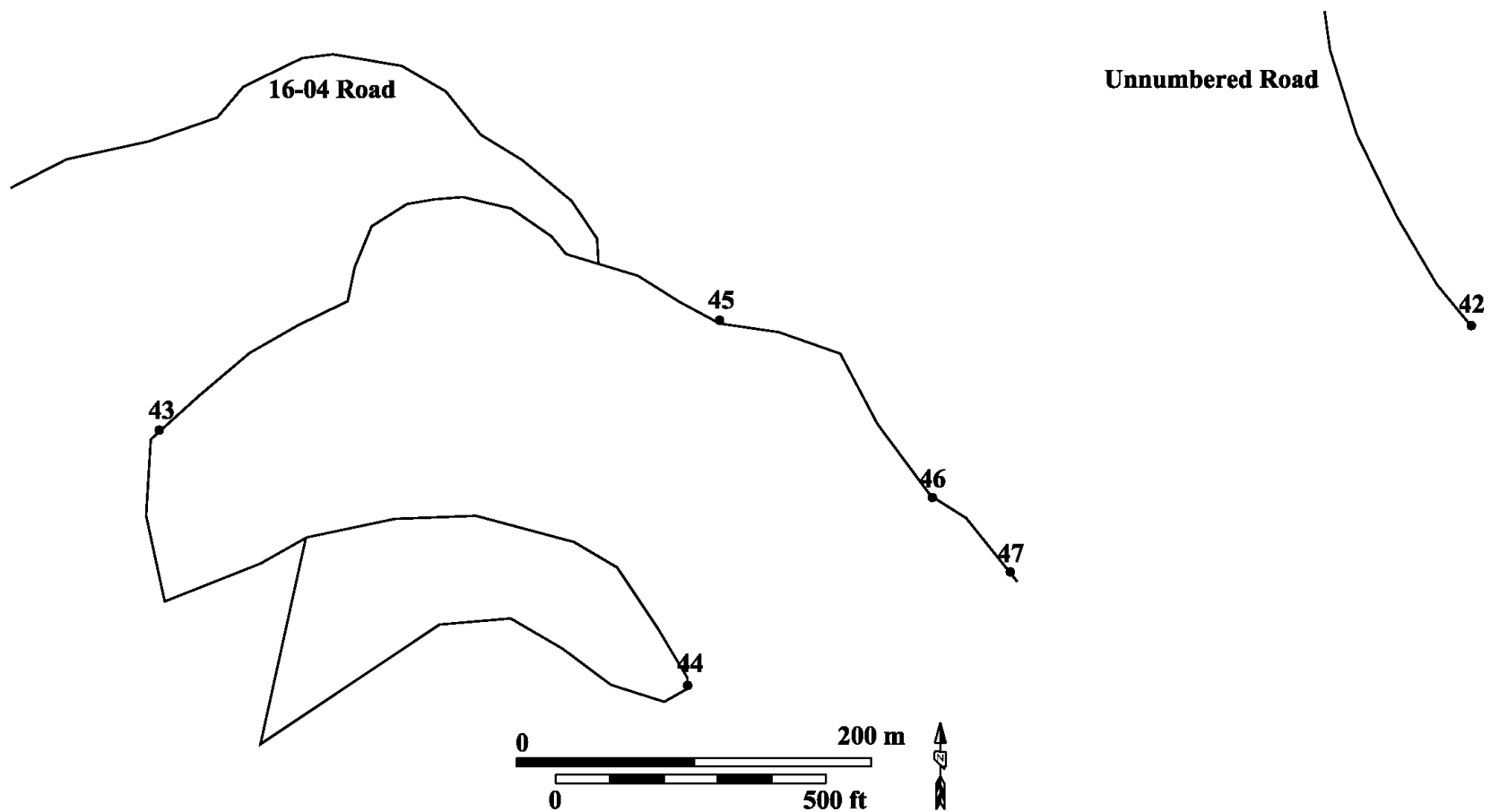


Figure 40. Location map of drill holes and vent, features 42-47, for U16a Tunnel.

Table 6. List of Features at the U16a Tunnel Complex.

Feature #	Feature Type	UTM Easting	UTM Northing
1	U16a Tunnel Portal	571630	4096305
2	Concrete Pads- Terminal Board	571645	4096301
3	Concrete Pad - Tunnel Blowers	571646	4096301
4	Concrete Foundation - Welding Shop	571661	4096302
5	Pipes	571661	4096297
6	Power Poles	571690	4096308
7	Sign and Box	571711	4096291
8	Explosives Magazine	571619	4096168
9	Concrete Pads - Blower Pad	571728	4096325
10	Rail Lines	571653	4096311
11	Camel Back Dump	571689	4096374
12	Concrete Pad - Construction Shop	571708	4096401
13	Sign	571709	4096436
14	Barricade	571704	4096448
15	Switch Boxes	571688	4096481
16	Post and Panel Boxes	571595	4096427
17	Electrical Transformer/Substation	571610	4096398
18	Concrete Foundation - Assembly Building 16-101	571632	4096399
19	Concrete Pad	571634	4096407
20	Concrete Foundation - Building 16-100	571661	4096349
21	Electrical Panel Backboards	571609	4096379
22	Concrete Pad	571630	4096344
23	Cable Holes	571623	4096331
24	Electrical Transformer/Substation	571575	4096337
25	Light	571595	4096332
26	Light Fixture	571598	4096341
27	Vent Tubing	571580	4096351
28	Light Fixture	571600	4096397
29	Pipe and T Posts	571590	4096280

Continued

Table 6. List of Features at the U16a Tunnel Complex, continued.

Feature #	Feature Type	UTM Easting	UTM Northing
30	Light Fixture	571594	4096276
31	Painted Boulder and Insulated Cable Fragments	571572	4096283
32	Electrical Transformer/Substation	571577	4096244
33	Pipe	571572	4096255
34	Pipe	571547	4096247
35	Barrel	571563	4096196
36	Communications Panel	571531	4096194
37	Transmitting Station	571528	4096197
38	Cable Hole (U16a CH#3), Cable Trough, Pipe	571496	4096204
39	Instrument Trailer Park - Fort Morgan	571512	4096252
40	Barrel	571512	4096339
41	Tower	571575	4096448
42	U16a Vent and Blower Assembly	571339	4096113
43	U16a.04 PS #1V Drill Hole	570602	4096053
44	UE-16a #1 Drill Hole	570914	4095912
45	U16a.03 PS #1A and PS #1AS Drill Hole	570914	4096115
46	U16a PS #2 W/S Drill Hole	571035	4096016
47	U16a PS#1 Drill Hole	571082	4095978



Figure 41. U16a Tunnel Feature 1, Portal, view west (2011).

bolts have been drilled into the sides and back of the tunnel and wire mesh has been rock bolted to the rock face above and around the portal.

Feature 2

Feature 2 consists of four partially buried concrete pads at UTM coordinate 571645 E, 4096301 N. The largest is 1.22 x 1.22 m (4 x 4 ft) and has rebar and bolts protruding through the surface (Figures 39 and 42). One piece of concrete measures 0.91 x 0.91 m (3 x 3 ft) and has bolts cut flush with the surface. Two final two pieces of concrete measure 0.46 x 0.46 m (18 x 18 inches) and have bolts cut flush with their surface. All the concrete is aligned at 15 degrees. The concrete may be the support for the Terminal Board shown on engineering JS-016-U16a.04C2.B, dated December 1968 (Figure 43).

Feature 3

Feature 3 is a concrete pad that measures 1.22 x 1.22 m at UTM coordinate 571646 E, 4096301 N (Figures 39 and 44). Centered in the pad is a piece of 22.86 cm (9 inch) pipe that has been cut flush with the surface. The pad is aligned at 0 degrees. The concrete may be a support for the Tunnel Blowers shown on engineering drawing JS-016-U16a.04C2.B, dated December 1968 (Figure 423).

Feature 4

Feature 4 is a six-sided concrete foundation for the Welding Shop at UTM coordinate 571661 E, 4096302 N. It measures 7.62 m north-south by 6.4 m (21 ft) east-west (Figure 45). Various sized conduits have been cut flush with the surface. The pad is aligned at 0 degrees. The location for the pad corresponds to the Welding Shop as shown on engineering drawings JS-016-U16a.04C2.B, dated December 1968 (Figure 43). Associated artifacts are wire, nails, I beam, and shrapnel.

Feature 5

Feature 5 is a series of seven vertical 22.86 cm pipes (Figures 39 and 46). The western most pipe (pipe #1) is at UTM coordinate 571661 E, 4096302 N, near the northeast corner of Feature 4, and has been cut flush with the surface. Pipe #2 is 4.8 m (15.7 ft) southeast of Pipe #1 and has been cut flush with the surface. Pipe #3 is 8 m (26.25 ft) east of Pipe #2 and extends 15.24 cm (6 inches) above the surface. Pipe #4 is 6 m (19.68 ft) east of Pipe #3 and extends 53.34 cm (21 inches) above the surface. Pipe #5 is 4.12 m (13.5 ft) east of Pipe #4 and extends 81.28 cm (32 inches) above the surface. Galvanized eye bolts have been welded along the top edge on the west side and four 3.81 cm (1.5 inch) holes have been cut in the east and west sides (aligned and stacked vertically). Pipe #6 is 7.28 m (23.88 ft) northeast of Pipe #5 and extends 1.42 m (56 inches) above the surface. Four vertically aligned holes have been cut in the east and west sides of the pipe. One galvanized eye bolt has been welded to the northwest side of the pipe and metal rods have been welded to the northwest and southeast sides. Pipe #7 is 8.6 m (28.22 ft) southeast of Pipe #6 and extends 1.17 m (46 inches) above the surface.

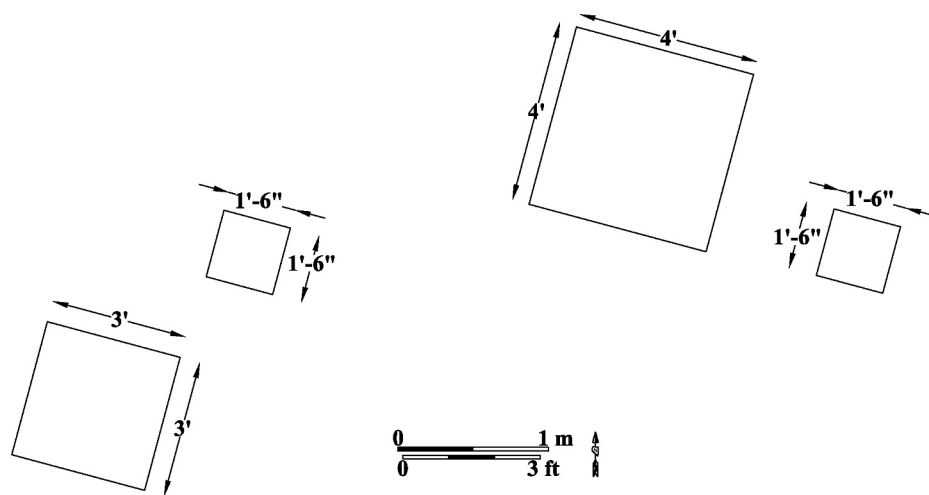


Figure 42. U16a Tunnel Feature 2, plan map and photograph of concrete pads, view northeast (2011).



Figure 44. U16a Tunnel Feature 3, concrete blower pad, view east (2011).

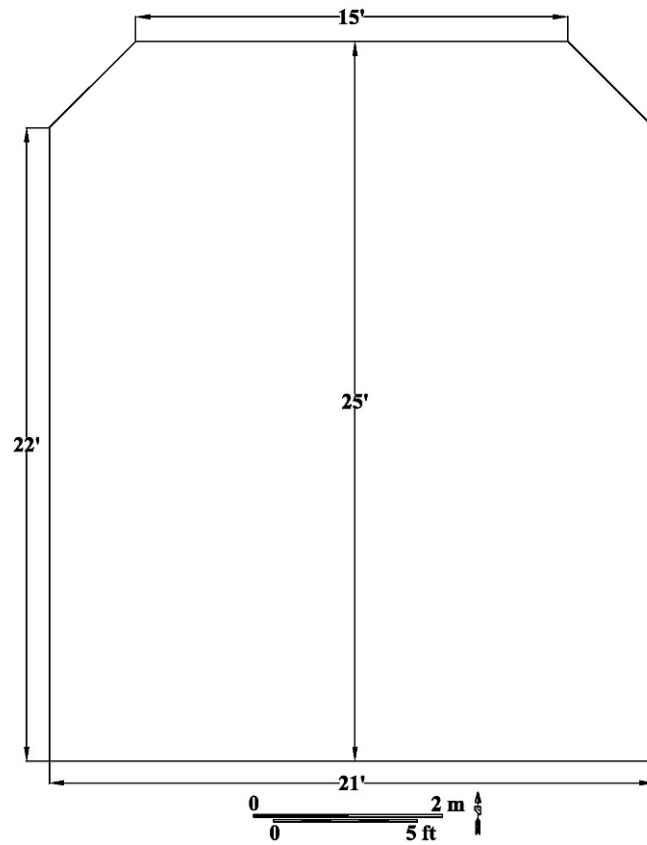


Figure 45. U16a Tunnel, Feature 4, plan map and photograph of concrete foundation for Welding Shop, view southeast (2011).

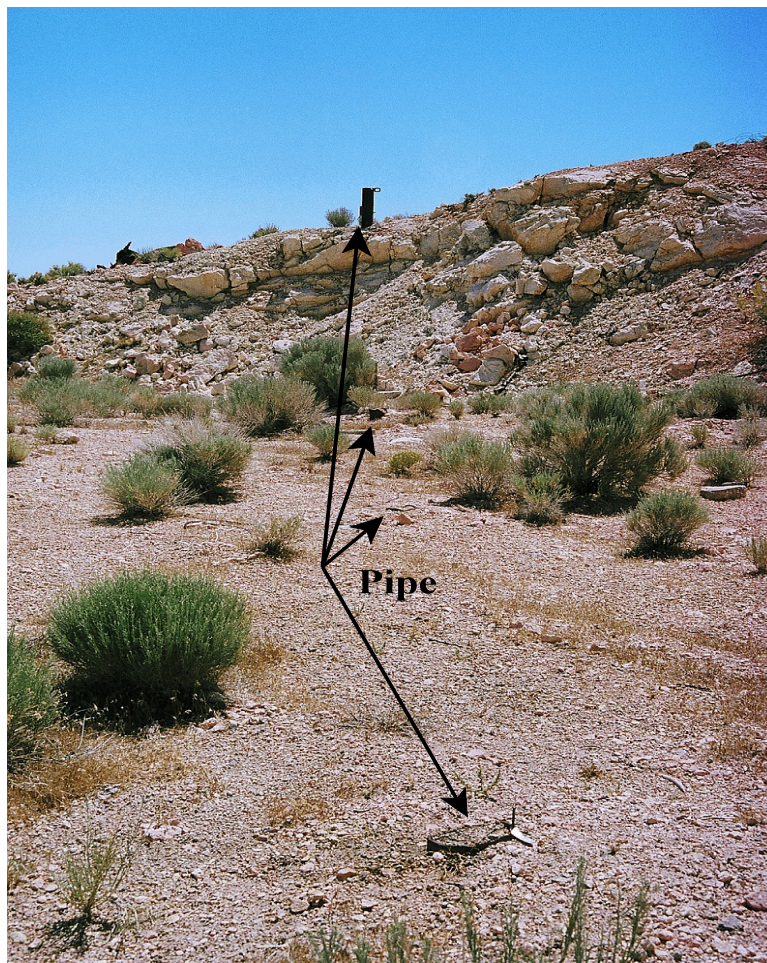
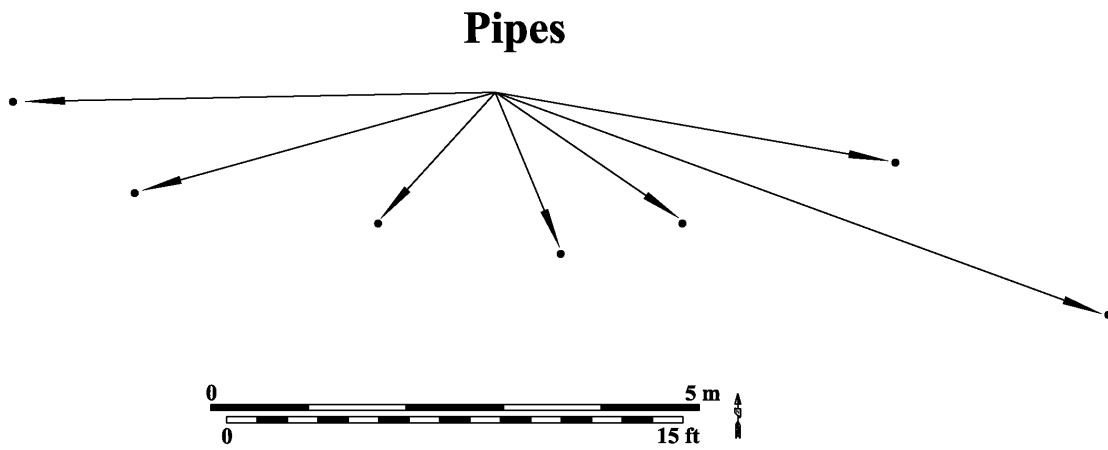


Figure 46. U16a Tunnel Feature 5, plan view and photograph of pipes, view southeast (2011).

Feature 6

Feature 6 consists of nine wood power poles in various locations across the Portal area that are part of the power grid that supplied power to the U16a Tunnel (Figures 39 and 47). Generally the poles are 30.48 cm (12 inches) in diameter and 11.58 m (38 ft) tall. Metal tags attached to some of the poles are dated 1987 and 1988 for Butt Testing. Other power poles of the power grid are in association with other features and are described with those features. Associated with the poles are ceramic insulators, metal braces, wood cross bars, and wire.

Feature 7

Feature 7 is a sign and metal box at UTM coordinate 571711 E, 4096291 N (Figures 39 and 48). The 60.96 x 30.48 cm (2 x 1 ft) metal sign is attached to a 1.22 m metal post with a 45.72 x 45.72 cm (18 x 18 inch) metal base. Signage is EXPLOSIVE MAGAZINE KEEP OUT. The metal box is for the storage of combustible materials (matches, lighters, etc.) during access to the magazine. The box measures 33.02 x 16.51 x 16.51 cm (13 x 6.5 x 6.5 inches) and is attached to a 10.16 cm (4 inch) channel iron post that is 1.14 m (45 inches) tall and embedded in the surface. The box lid has a wire bail handle and a 10.16 cm butt hinge. Signage on the box is PLACE SMOKING DEVICES HERE.

Feature 8

Feature 8 is an explosives magazine, fire extinguisher stand, and stanchions at UTM coordinate 571619 E, 4096168 N (Figures 39 and 49). The magazine is made from line-of-sight pipe that is 2.74 m (9 ft) in diameter and 3.66 m (12 ft) in length. It is aligned at 0 degrees. Two 15.24 cm I beams are welded to the bottom and extend the length of the line-of-sight pipe. The I beams are supported by 8 x 8 inch milled lumber beams lying on the surface. Metal plates have been welded to the ends of the line-of-sight pipe to enclose the structure. A 0.91 x 2.13 m (3 x 7 ft) metal door is centered in the south end of the magazine. It is attached to the metal plate with six 12.7 cm (5 inch) butt hinges. The interior of the magazine consists of a plywood floor, shelving, lighting, and a metal rack. On each side of the door are 71.12 x 71.12 cm (28 x 28 inch) shelves made of angle iron and plywood. On the shelf on the west side of the door is a telephone (295-6757) with a Bechtel Nevada tag. On the northwest side is a 30.48 x 60.96 cm shelf made of angle iron and plywood. Lighting is by four double bulb florescent fixtures. In the center of the structure is a metal rack that is 1.83 m (72 inches) in length, 2.13 m (7 ft) in height, and 0.69 m (27 inches) in width. The rack has braces spaced 20.32 cm (8 inches) apart to support shelving. On one rack is a tag, #1 Whipple Camera V.G. #2-3 to Portal #2 16B. In the north end of the structure is a refrigerated air conditioning unit.

West of the magazine is a fire extinguisher stand made of plywood and metal T posts. The 3/4 inch plywood is 35.56 x 96.52 cm (14 x 38 inches) and attached to the top of the T posts that are embedded in the surface. A second fire extinguisher rack is 50 m (164 ft) northeast of the magazine along the access road. It is constructed similar to the one near the magazine. On the dirt pad in front of the magazine are four stanchions (eye bolts) for the attachment of an unknown object. Associated artifacts are wire, cable, wood, pipe, and a cable spool.

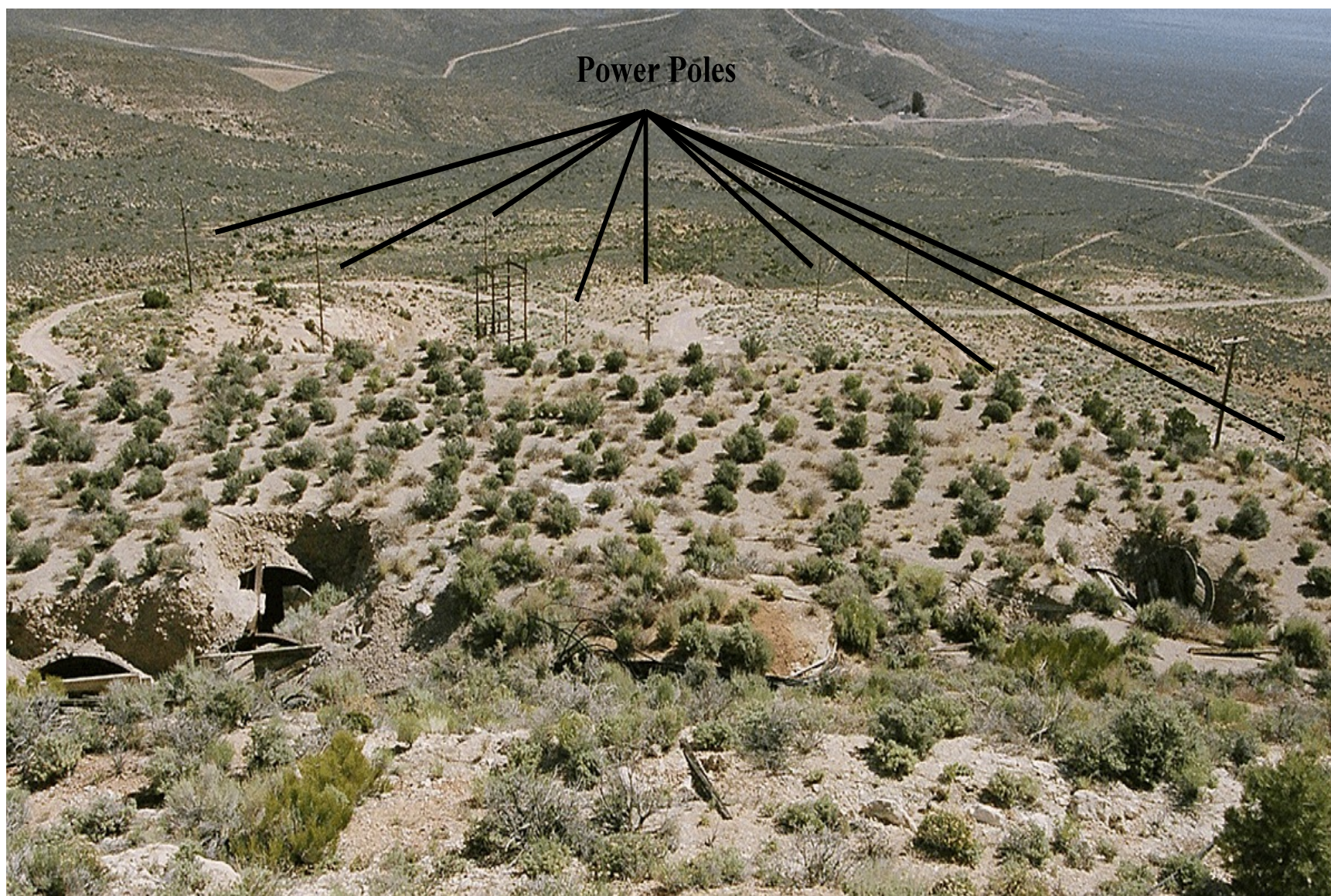


Figure 47. U16a Tunnel Feature 6, power poles, view northeast (2011).



Figure 48. U16a Tunnel Feature 7, sign and box (2011).

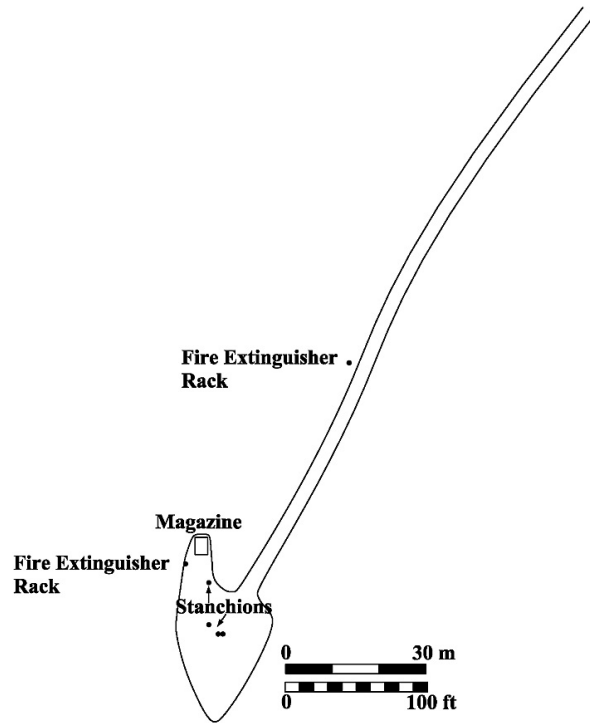


Figure 49. U16a Tunnel Feature 8, plan map and photograph of explosives magazine (2011).

Feature 9

Feature 9 consists of three concrete pads for the Blower Pad (Figures 39 and 50). The largest pad is L shaped, aligned at 317 degrees, and at UTM coordinate 571728 E, 4096325 N. The north side of the pad is 7.3 m (24 ft) east-west and the east side is 5.5 m (18 ft) north-south. The south side extends 3 m (10 ft) west from the southeast corner, turns 1.8 m (6 ft) north-south, and turns 4.3 m (14 ft) east-west to the south end of the west side. The west side extends 3.7 m (12 ft) north to the northwest corner of the pad. Bolts have been cut flush with the surface of the pad. The second pad measures 45.7 x 45.7 cm (18 x 18 inches) and is 0.3 m (11.8 inches) east of the northeast corner of the largest pad. The third pad is 0.91 x 0.61 m (3 x 2 ft) and is 5 cm (2 inches) south of the second pad. Associated artifacts are bolts, washers, metal fragments, conduit, wood, nails, and rubber fragments. The location of the pads corresponds to the Blower Pad shown on engineering drawing U16a.06 Portal Trailer Park, dated March 1971 (Figure 51).

Feature 10

Feature 10 is the rail lines for the engine and muck cars. The lines fan out from the portal across the Portal Pad (Figures 39 and 52). The rails are metal and spaced 0.91 m apart. Most of the rails are buried or missing and it is not clear how the rails are supported (wood or metal ties). No switches were found, but the rails do converge in several places.

Feature 11

Feature 11 is a camel back dump at UTM coordinate 571691 E, 4096384N (Figures 39 and 53). The structure consists of rail lines, the dump track (wheel guide), and two overhead platforms. The camel back was constructed on site and used to automatically dump muck cars into the muck dump area. It consists of two horizontal rails (Feature 10) that guide and support the muck cars to the camel back. Parallel to the rails is an inclined metal dump track 30.48 cm in width and braced with four vertical 15.24 cm I-beam posts. The posts vary in height up to 1.32 m (52 inches) in the center forming the incline (arch). As a muck car approaches the camel back, a tire attached to the side of the car makes contact with the dump track. As the track inclines, the tire raises and causes the muck car to rotate and dump its contents. As the car proceeds, the dump track declines and the car rotates back to its upright position. The rails, inclined posts, dump track, and platforms are welded to a metal frame made of 15.24 cm angle iron and I beam. The frame forms a lattice that is buried and only visible near the rail lines and platforms.

The lower of the two overhead platforms consists of a metal frame that is 3.05 m (120 inches) north-south by 1.32 m wide and 1.7 m (67 inches) in height. It is adjacent to the west side and extends parallel to the rail line for the muck cars. The platform is supported by 5.08 cm and 7.62 cm angle iron posts and has 2 x 12 inch milled lumber as decking, some of which is missing. Hand rails, along the north and west sides, are constructed of 1.9 cm (3/4 inch) rock bolts stamped 96 (possible length). The hand rail is 1.12 m (44 inches) above the decking. Centered over and extending perpendicular to the lower platform and over the dump track and rails is a 1.83 x 0.94 m (72 x 37 inch) metal frame

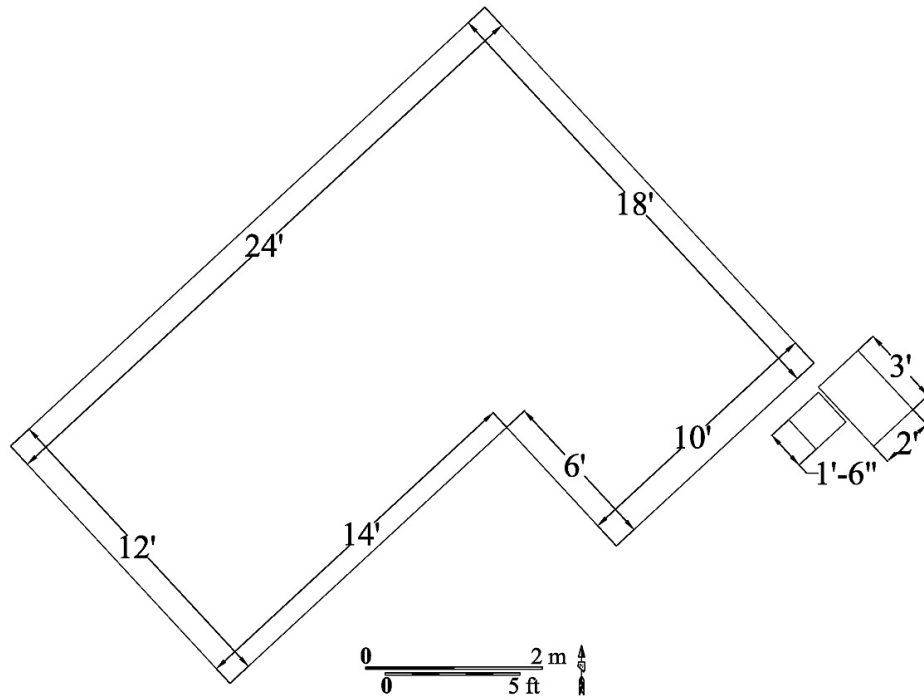


Figure 50. U16a Tunnel Feature 9, plan map and photograph concrete pads for Blower Pad, view north (2011).

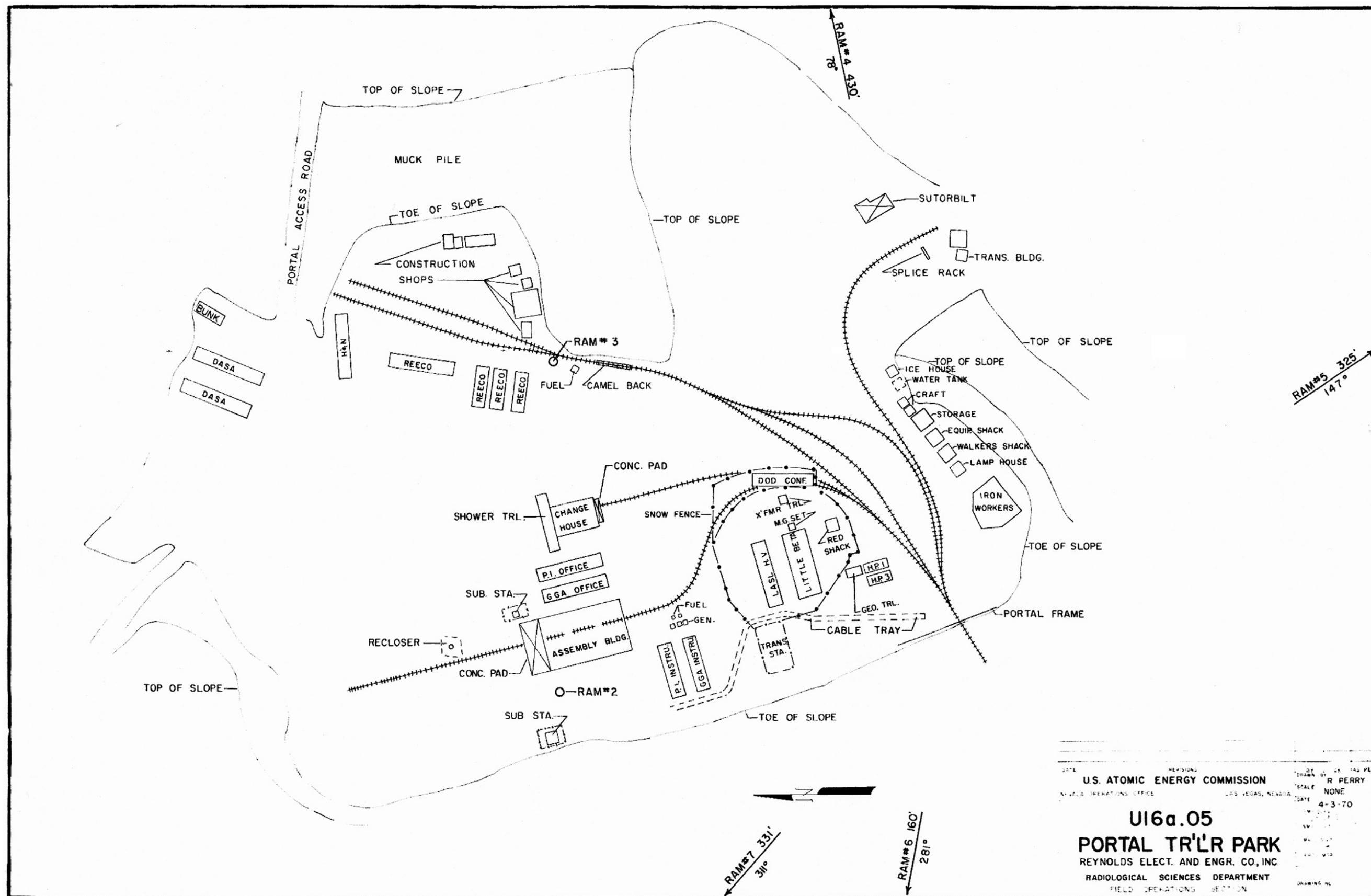


Figure 51. U16a Tunnel, U16a.05 Portal Trailer Park (on file at DOE Archives and Records Center).

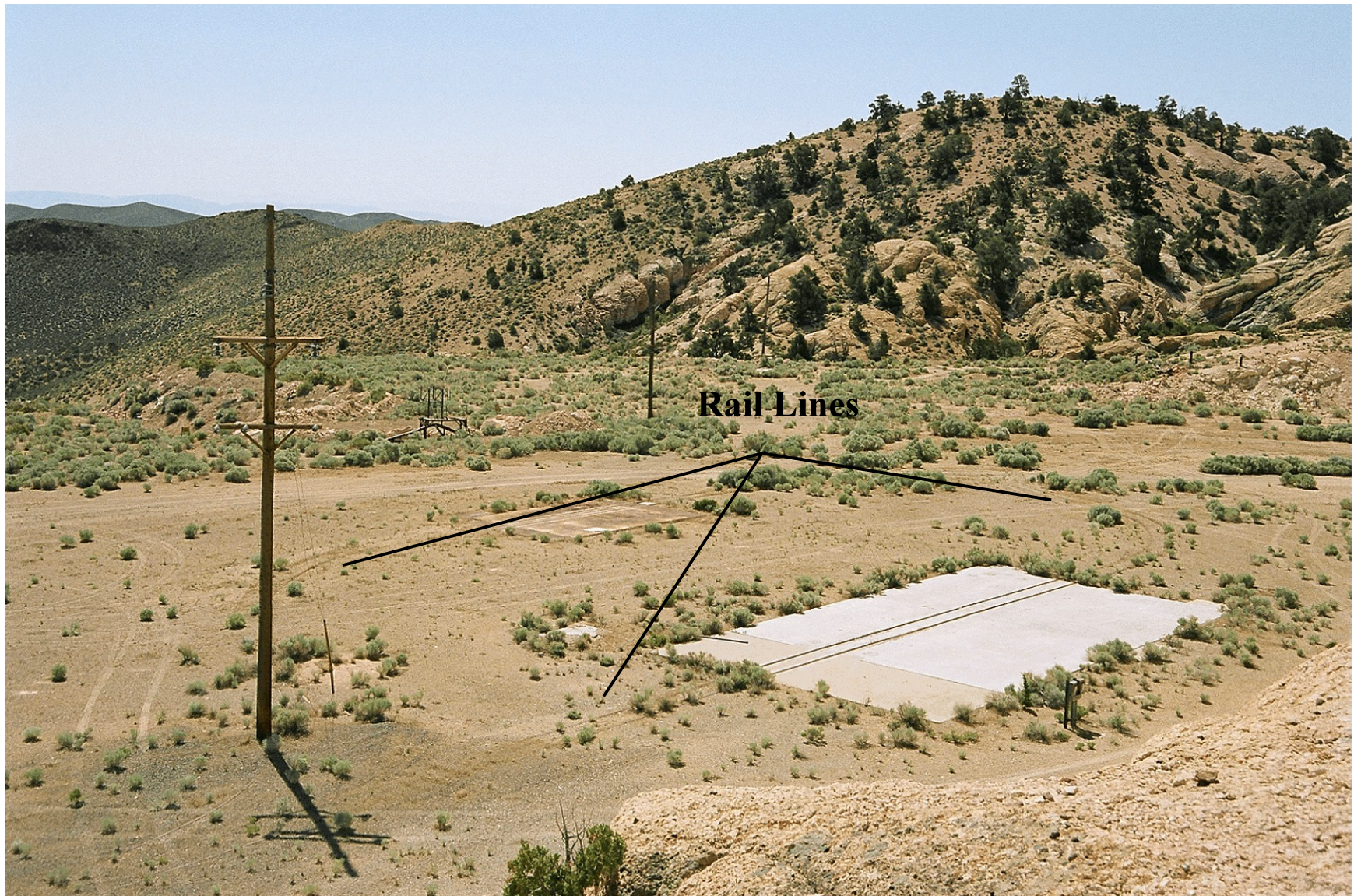


Figure 52. U16a Tunnel Feature 10, rail lines, view southeast (2011).



Figure 53. U16a Tunnel Feature 11, camel back dump, view northwest (2011).

platform constructed of angle iron, rebar, and expanded metal for the decking. This platform is 0.91 m above the lower platform. It has a hand rail made of angle iron and is 1.12 m above the expanded metal decking. This was used by the train swamper to observe the muck cars dumping and to remove any residual muck from the cars. The location for the Camel Back Dump corresponds to the one shown on engineering drawing JS-016-U16a.04-C2.B, dated December 1968 (Figure 43).

Feature 12

Feature 12 is a concrete pad at UTM coordinate 571708 E, 4096401 N (Figures 39 and 54). It measures 6.1 m (20 ft) north-south by 5.18 (17 ft) east-west. The concrete was rough poured (no smoothing) in two sections. The pad corresponds to one of the Construction Shops shown on engineering drawing U16a.05 TR'L'R Park, dated April 3, 1970 (Figure 51).

Feature 13

Feature 13 is a metal sign at UTM coordinate 571709 E, 4096436 N (Figures 39 and 55). It has a white background, a blue header box, and black lettering. The sign is on the surface, folded around the posts, and partially buried. It is possibly an entry restriction sign. The sign was supported by 4 x 4 inch wood posts that are 2.13 m in length.

Feature 14

Feature 14 is a metal barricade across the access road into the U16a Tunnel at UTM coordinate 571704 E, 4096448 N (Figure 39 and 56). The barricade consists of two similar triangular sections. Each is constructed with a vertical 15.24 cm channel iron post that is 2.49 m (98 inches) in height. Attached to the post is a 10.16 cm (4 inch) diameter horizontal pipe, 4.09 m (161 inches) in length, that extends from the vertical post to the center of the road. The horizontal pipe is attached to the vertical post with a hinge. The hinge consists of two metal plates that extend parallel to and are welded in the end of the horizontal pipe. Two similar metal plates are welded to the side of the post. The plates are joined by a vertical metal pin that extends through a hole in the plates on the post and pipe. A 10.16 cm pipe brace is attached to the vertical post 66.04 cm (26 inches) below the horizontal pipe. It is attached to the post with a hinge similar to the one above. The brace extends diagonally 2.03 m (80 inches) and is welded to the bottom of the horizontal pipe forming a triangle. Stop signs are welded to each section of the barricade. The two sections of the barricade are secured with a chain and lock.

Feature 15

Feature 15 consists of four sets (2 per backboard) of electrical switch boxes along the north edge of a dirt pad (Figures 39 and 57). Each switch box is mounted to a 3/4-inch plywood backboard that is attached to two 4 x 4 inch wood posts that are 1.42 m (56 inches) in height. Electrical cable extends below the surface through 8.89 cm (3.5 inch) galvanized conduit. The switch boxes are spaced approximately 8 m apart. The plywood backboard on the third panel box (from east) is lying on the surface; however, the panel boxes remain upright.



Figure 54. U16a Tunnel Feature 12 construction shop pad, view southwest (2011).



Figure 55. U16a Tunnel Feature 13 metal sign, view east (2011).



Figure 56. U16a Tunnel Feature 14, barricade (2011).



Figure 57. U16a Tunnel Feature 15, switch boxes, view northwest (2011).

Feature 16

Feature 16 is three aluminum communication panel boxes at UTM coordinate 571595 E, 4096427 N (Figures 39 and 58). They are mounted to a 4 x 6 inch wood post that is 1.88 m (74 inches) in height.) On the east side of the post is a 53.34 x 21.59 x 7.62 cm (21 x 8.5 x 3 inch) communication panel box. On the west side are two 22.86 x 6.35 x 12.7 cm (9 x 2.5 x 5 inch) Western Electric communication panel boxes.

Feature 17

Feature 17 is an electrical transformer/substation at UTM coordinate 571610 E, 4096398 N (Figures 39 and 59). The feature consists of a fenced area, milled lumber supports, and a metal stand. The fenced area is 3.05 m east-west by 3.96 m (13 ft) north-south and is aligned at 0 degrees. The fence is constructed of 7.62 cm diameter vertical pipe corner posts 2.51 m (99 inches) in height. Chain link fencing is welded to the posts and three strands of barbed wire top the fence. Entrance into the area is through a 1.42 m wide gate that is 2.79 m (110 inches) in height. Support for the transformer (now missing) is a 2 x 12 inch milled lumber deck (floor) that is 2.44 m north-south by 1.52 m east-west. Adjacent to the west edge of the deck is a metal stand that is 76.2 x 43.18 x 50.8 cm (30 x 17 x 20 inches). Extending from the stand are two 7.62 cm galvanized conduits containing wire. The location for the Electrical Transformer Station corresponds to the one shown on engineering drawing JS-016-U16a.04-C2.B, dated December 1968 (Figure 43).

Feature 18

Feature 18 is the concrete foundation for the Assembly Building 16-101 at UTM coordinate 571632 E, 4096399 N (Figures 39 and 60). It consists of a 12.19 m (40 ft) east-west by 23.77 m (78 ft) north-south concrete pad that is aligned at 345 degrees. A 2.13 x 1.22 m (7 x 4 ft) concrete pad for a pedestrian entrance is 40.64 cm (16 inches) west of the southeast corner and a similar pad is at the southwest corner of the foundation. A 3.05 x 1.22 m concrete entrance pad is along the west side of the foundation 8.23 m (27 ft) north of the southwest corner. Two metal rail lines (Feature 10) extend north-south the length of the foundation. They are 4.01 m (158 inches) from the east edge of the pad and 0.91 m apart. Two electrical switch boxes are near the Assembly Building (Feature 18) pad. They are mounted to a 3/4 inch plywood backboard that is 76.2 x 60.96 cm (30 x 24 inches). The backboard is attached to two 4 x 4 inch posts that are 1.52 m (60 inches) in height. Extending from the switch boxes are 7.62 cm galvanized conduits. The location for the Assembly Building corresponds to the one shown on engineering drawing JS-016-U16a.04-C2.B, dated December 1968, drawing U16a.06, dated March 1971, and drawing 016-002-C1.4, dated May 1970 (Figures 43, 51, and 61).

Feature 19

Feature 19 is a concrete pad at UTM coordinate 571634 E, 4096407 N (Figure 62). The pad is 2.44 m north-south and 1.83 m east-west and aligned at 345 degrees. A 7.62 cm galvanized conduit with insulated cables is centered along the west edge of the pad. The conduit has been cut off near the surface of the pad.



Figure 58. U16a Tunnel Feature 16, post and communications panel boxes, view north (2011).

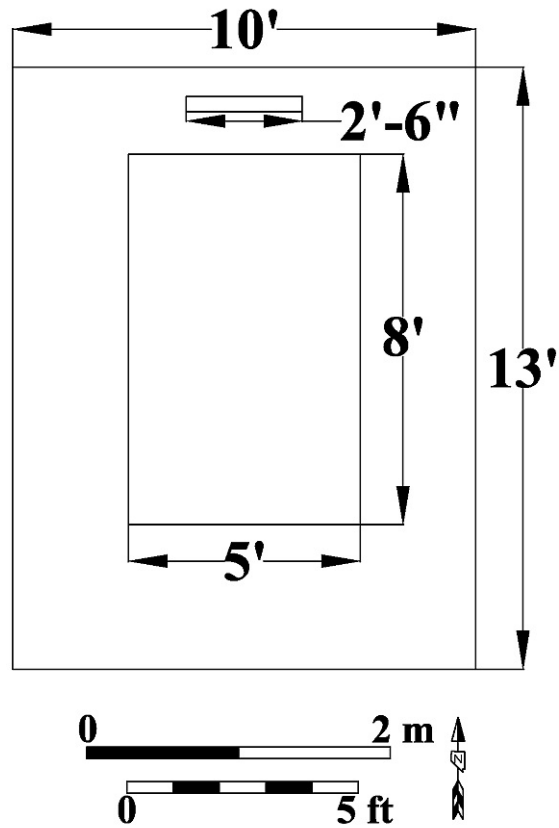


Figure 59. U16a Tunnel Feature 17, plan map and photograph of transformer station, view southwest (2011).

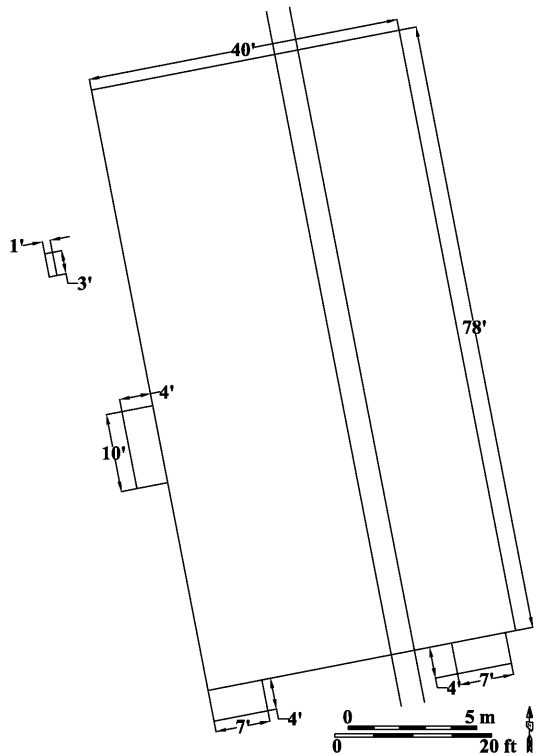


Figure 60. U16a Tunnel Feature 18, plan map and photograph of foundation for Assembly Building 16-101, view southeast (2011).

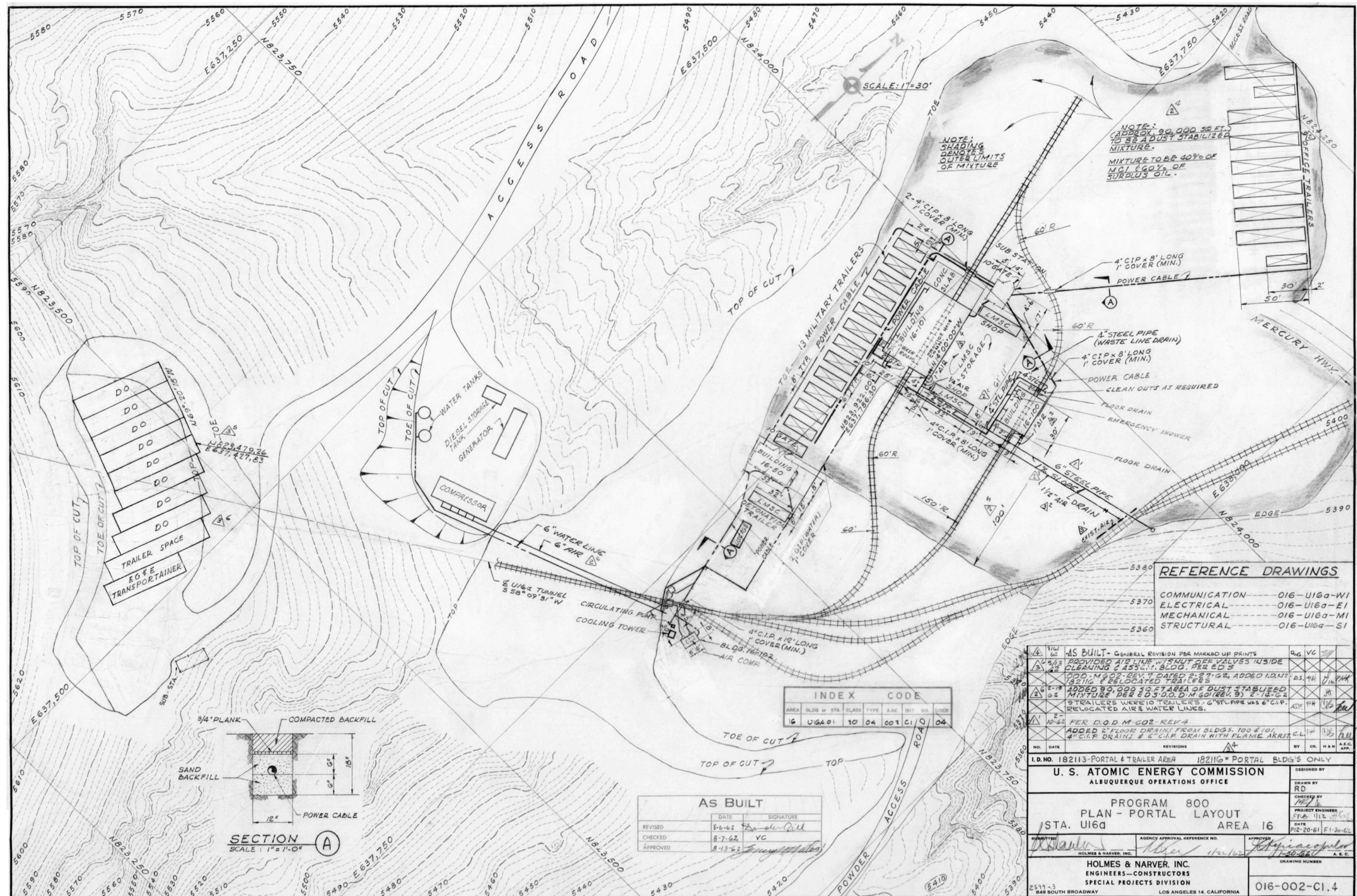




Figure 62. U16a Tunnel Feature 19, concrete pad, view southeast (2011).

Feature 20

Feature 20 is a concrete foundation for Building 16-100 at UTM coordinate 571661 E, 4096394 N (Figures 39 and 63). It is 10.36 m (34 ft) east-west and 9.14 m (30 ft) north-south and aligned at 345 degrees. Along the east edge at the northeast corner is a 1.22 x 2.13 m concrete pedestrian entrance pad. Along the north edge is a 6.4 x 1.22 m (21 x 4 ft) concrete ramp 1.07 m (42 inches) from the northeast corner. A similar concrete ramp is 1.07 m from the southeast corner along the south edge. A 0.91 x 0.91 m access plate for a drainage is 1.9 m (75 inches) from the north edge and 30.48 cm from the west edge of the pad. Two 10.16 cm pipes in the bottom of the drainage exit through the west edge of the pad. Two metal rail lines (Feature 10) extend north-south across the pad. They are 2.18 m (86 inches) from the east edge and 0.91 m apart. Centered between the rails adjacent to the south concrete ramp is a drain covered with a 0.91 x 0.91 m metal grate. Centered in the bottom of the drain is a 20.32 cm pipe. On the 1968 engineering drawing JS-016-U16a.04-C2.B (Figure 43), the feature is listed as a concrete pad adjacent to the Shower Trailer and as a Change House on engineering drawing U16a.06, dated March 1971 (Figure 51).

Feature 21

Feature 21 is two electrical panel backboards with no electrical panels attached. The first panel is at UTM coordinate 571609 E, 4096379 N (Figures 39 and 64). It is constructed of 3.81 cm channel iron, is 1.52 m in height, and is 1.83 m in length. Fragments of cables are still attached to the backboard. The second panel is at UTM coordinate 571610 E, 4096378 N. It is the same construction and size as the first panel but no cables remain attached to this backboard.

Feature 22

Feature 22 is a concrete pad at UTM coordinate 571630 E, 4096344 N (Figures 39 and 65). The pad is 8.23 m (27 ft) east-west by 3.66 m (12 ft) north-south and aligned at 240 degrees. Various sized conduits and bolts have been cut flush with the surface.

Feature 23

Feature 23 is four holes drilled horizontally into the rock face of Shoshone Mountain at UTM coordinate 571623 E, 4096331 N (Figures 39 and 66). The holes are 8.89 cm (3.5 inch) in diameter and provide cable access into a drift off of the U16a tunnel. They were used during the Divine Kingfisher 31 high explosives test in 2001. Associated artifacts include cable fragments, broken concrete, communication wire, and wood fragments.

Feature 24

Feature 24 is an electrical transformer/substation at UTM coordinate 571575 E, 4096337 N and an elevation of 1,676 m (5,500 ft). The feature consists of a chain-link fence, a concrete pad, and four power poles (Figures 39 and 67). The fence is 6.1 m east-west by 9.45 m (31 ft) north-south and 2.44 m in height. Three strands of barbed wire are attached to the top of the fence. Two 1.52 m wide gates on the west side provided access into the fenced area. The concrete pad is 3.66 x 3.66 m. The four

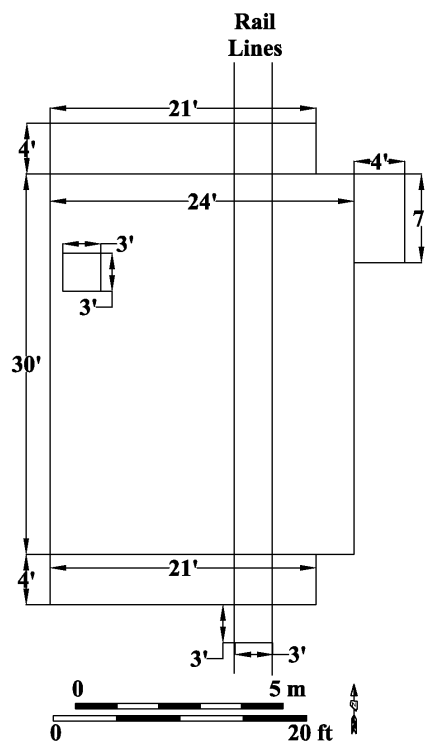


Figure 63. U16a Tunnel Feature 20, plan map and photograph of foundation for Building 16-100, view southeast (2011).



Figure 64. U16a Tunnel Feature 21, electrical panel backboards, view west (2011).



Figure 65. U16a Tunnel Feature 22, concrete pad, view west (2011).



Figure 66. U16a Tunnel Feature 23, cable holes, view southwest (2011).



Figure 67. U16a Tunnel Feature 24, electrical substation, view southeast (2011).

power poles are approximately 30.5 cm in diameter and are near the four corners of the concrete pad. The four poles are connected at the top with wood braces. Fuses (cut outs) are on wood braces between the northern poles. Associated artifacts are broken ceramic insulators, wire, and wood.

Feature 25

Feature 25 is a light at UTM coordinate 571595 E, 4096332 N and an elevation of 1,676 m. It is an aluminum light that is 66.04 x 50.8 x 30.48 cm. The inside of the light is highly polished and has a single bulb for illumination (Figures 39 and 68). The light is lying on the surface.

Feature 26

Feature 26 is light fixture at UTM coordinate 571598 E, 4096341 N and an elevation of 1,673 m. It consists of 1.83 m tall pipe pole with two aluminum lights that are 66.04 x 50.8 x 30.48 cm. The inside of the fixtures are highly polished and have a single bulb for illumination (Figures 39 and 69). The two lights are mounted separately to the top of a pole and can be rotated horizontally and vertically to change the direction of the light.

Feature 27

Feature 27 is a piece of vent tubing from at UTM coordinate 571580 E, 4096351 N and an elevation of 1,673 m. The tube is 76.2 cm in diameter and is a 90-degree coupling (elbow) generally associated with vent tubing or a blower assembly for ventilation of the tunnels (Figures 39 and 70).

Feature 28

Feature 28 is a light fixture at UTM coordinate 571600 E, 4096397 N and an elevation of 1,664 m (5,460 ft). It consists of 1.83 m tall pipe pole with two aluminum lights that are 66.04 x 50.8 x 30.48 cm. The inside of the lights are highly polished and have a single bulb for illumination (Figures 39 and 71). The lights are mounted to the end of a 60.1 cm cross bar mounted to the top of the pole. A WIDE LIGHT REACTOR BALLAST is mounted on the pole under each light (two ballasts).

Feature 29

Feature 29 is a piece of 71.12 cm diameter pipe and metal T posts at UTM coordinate 571590 E, 4096280 N and an elevation of 1,686 m (5,540 ft). It extends 30.48 cm above the surface and has a 1.22 x 1.22 m sheet of 1.27 cm (1/2 inch) thick steel plate welded to the open end of the pipe (Figures 39 and 72). A #1 is painted on top of the plate and a D shackle is welded to the southwest corner of the plate. The metal T posts are near the southwest, southeast, and northeast corners of the metal plate. The pipe was used during the later high explosives testing. Features 29, 30, and 31 are on a small dirt pad that was the location for water tanks, a compressor, diesel storage tanks, and a generator in 1962 (see Figure 61).



Figure 68. U16a Tunnel Feature 25, light, view northeast (2011).



Figure 69. U16a Tunnel Feature 26, light fixture, view southwest (2011).



Figure 70. U16a Tunnel Feature 27, vent tubing, view northwest (2011).



Figure 71. U16a Tunnel Feature 28, light fixture, view south (2011).



Figure 72. U16a Tunnel Feature 29, pipe, view south (2011).

Feature 30

Feature 30 is a light fixture at UTM coordinate 571594 E, 4096267 N, and an elevation of 1,691 m (5,550 ft). The light pole is a piece of 3.81 cm channel iron 1.83 m in length (Figures 39 and 73). The light fixture is labeled STEBER and is 45.72 cm in diameter and 40.64 cm in length. It has a single 10.16 cm diameter bulb with a plastic cover that seals the fixture.

Feature 31

Feature 31 is a painted boulder and insulated cable fragments at UTM coordinate 571572 E, 4096283 N and an elevation of 1,691 m (Figures 39 and 74). The boulder is part of loose debris (boulders, rocks, etc.) from the adjoining slope. One broken boulder has #2 is painted on one side. The cable is fragments that are 1.9 cm (3/4 inch) in diameter and partially hidden in the debris. Associated artifacts are insulated wire, shrapnel, and wood.

Feature 32

Feature 32 is an electrical transformer/substation at UTM coordinate 571577 E, 4096244 N and an elevation of 1,695 m (5,560 ft). The station consists of a chain-link fenced area, two concrete pads, electrical panel backboard, power poles, and cables and conduits (Figures 39 and 75). The partially fenced area is 7.01 m (23 ft) north-south by 9.45 m east-west and 2.44 m tall. The fence is only on the east and south sides. There is a 1.52 m wide gate in the south fence at the west corner. The west side of the fenced area, along the slope, has been shored with 2 x 12 inch milled lumber 4.27 m (14 ft) in length. The first concrete pad is 4.27 m (14 ft) north-south by 3.35 m (11 ft) east-west by 76.2 cm thick. On the east side of the pad and 2.03 m from the northeast corner are 7.62 cm electrical conduits 2.03 m in height. The second concrete block is 4 ft east-west by 5 ft north-south and is 1.5 m east of the first block. The electrical panel backboard is a 4 x 4 sheet of 3/4 inch plywood attached to 4 x 4 inch posts that are 1.73 m (68 inches) in height. Attached to the backboard is a 600 amp 25.4 x 45.72 x 127 cm switch box. The power pole is 30.48 cm in diameter and approximately 7.62 m in height. It has two cross bars near the top. Electrical conduit and cable extends from the subsurface in several areas within the fenced area. Associated artifacts are plywood, insulated cable fragments, and 2 x 12 inch milled lumber.

Feature 33

Feature 33 is a vertical pipe extending from the subsurface at UTM coordinate 571572 E, 4096255 N and an elevation of 1,695 m. It is 66.04 cm diameter spiral weld pipe that extends 30.48 cm above the surface (Figures 39 and 76). The cover for the pipe is a 71.12 cm diameter piece of diamond plate with a #3 painted on the top and side. The pipe was used during the later high explosives testing.

Feature 34

Feature 34 is a vertical pipe extending from the subsurface at UTM coordinate 571547 E, 4096247 N and an elevation of 1,670 m (5,480 ft) (Figures 39 and 77). The pipe is 60.1 cm diameter and extends 15.24 cm above the surface. The end is sealed with expanded metal welded to the inside of the pipe. A 1.22 x 1.22 m metal plate that is 1.27 cm thick with a #4 painted on the top is welded to



Figure 73. U16a Tunnel Feature 30, light fixture, view south (2011),



Figure 74. U16a Tunnel Feature 31, painted boulder and insulated cable fragments, view southwest (2011).

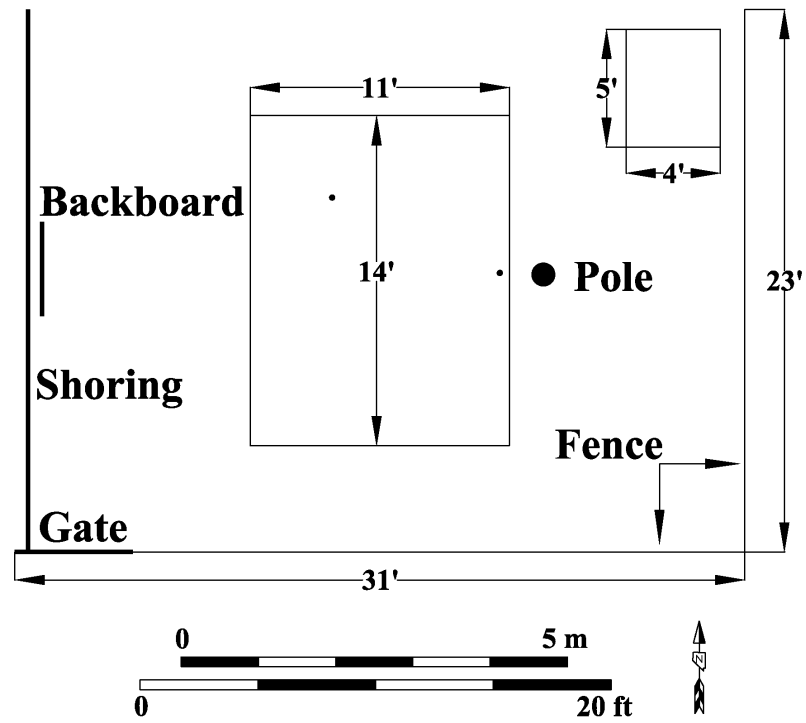


Figure 75. U16a Tunnel Feature 32, plan map and photograph of electrical substation, view east (2011).



Figure 76. U16a Tunnel Feature 33, pipe, view south (2011).



Figure 77. U16a Tunnel Feature 34, pipe, view northeast (2011).

the end of the pipe. Access through the plate is by a 91.44 x 61 cm hinged metal door. The casing was used during high explosives testing.

Feature 35

Feature 35 is a buried barrel at UTM coordinate 571563 E, 4096196 N and an elevation of 1,695 m. The barrel is 61 cm in diameter and extends 15.24 cm above the surface (Figures 39 and 78). The bottom of the barrel is filled with concrete, leaving 61 cm of empty space in the barrel. A 1.9 cm (3/4 inch) metal pipe 1.2 m in length extends from the barrel.

Feature 36

Feature 36 is a communications panel at UTM coordinate 571531 E, 4096194 N and an elevation of 1,713 m (5,620 ft). The panel is aluminum and measures 43.18 x 17.78 x 5.08 cm (17 x 7 x 2 inches) and is mounted to a 4 x 6 inch post that is 2.29 m (90 inches) in height (Figures 39 and 79). Metal numbers attached to the post are 14-2 and 1-0.

Feature 37

Feature 37 is a transmitting station at UTM coordinate 571528 E, 4096197 N and an elevation of 1,713 m. It consists of a pipe frame and a wood platform for a brockhouse (Figures 39 and 80). The frame is made of 5.08 cm metal pipe risers that are 6.1 m in height and 1.52 m apart. A 5.08 cm pipe cross bar connects the top end of the two risers. At the base of the frame is a 1.83 x 1.83 m wood platform constructed of 2 x 4 and 2 x 6 inch milled lumber and 3/4 inch plywood. The platform is the floor for a wood brock house. The floor joists are 2 x 6 inch and are attached to two 4 x 6 inch skids. Scattered lumber and wood fragments near the platform are the walls and roof of the brock house. The roof section is covered with rolled roofing. Associated artifacts are milled lumber, electrical conduit, a switch box and a wood ladder. The U16a transmitting station brockhouse is shown on engineering drawing JS-016-U16a-S11.1, dated July 1962 (Figure 81).

Feature 38

Feature 38 is a cable hole, cable trough, and pipe at UTM coordinate 571496 E, 4096204 N and an elevation of 1,719 m (5,640 ft) (Figure 82). This is the U16a CH#3 cable hole that is 150.6 m (494 ft) in depth. According to Bennett (1991), the cable hole was drilled from the tunnel to the surface. No casing was installed in the bedrock and the area around the cable hole is covered with rocks and boulders obscuring its exact location. Insulated cable extends from the rock rubble in the area of the cable hole, along the surface, and is within the remains of the cable trough. The cable trough extends approximately 22 m (72 ft) from the north trailer emplacement at the trailer park to the area near the cable hole. The cable trough is highly deteriorated and collapsed. The trough was constructed of 2 x 4, 2 x 12, 4 x 4 and 4 x 6 inch milled lumber similar to the one shown on engineering drawing JS-016-U16a-S7.1 (Figure 83). The area around the cable trough is unstable and large areas have collapsed into the covered trailer locations. Three pieces of 2.54 cm pipe extend 1 m above the surface. Each pipe has a 2.54 cm valve on the end and grout has hardened in the end of the valves. This is one of the locations where grout was injected into the bedrock in an attempt to seal cracks.



Figure 78. U16a Tunnel Feature 35, barrel, view southeast (2011).



Figure 79. U-16a Tunnel Feature 36, post and communications panel, view south (2011).



Figure 80. U16a Tunnel Feature 37, transmitting station, view southeast (2011).

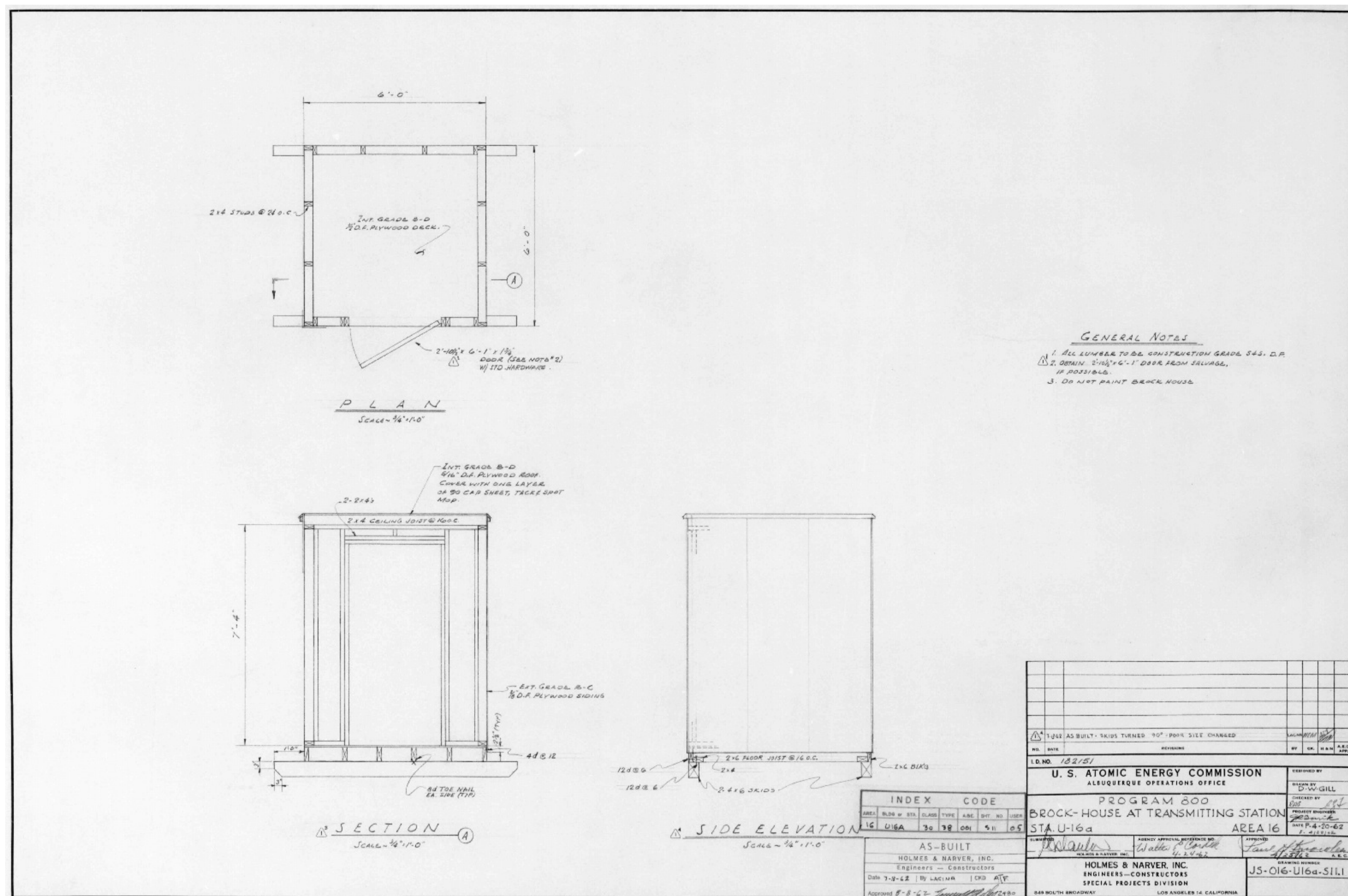


Figure 81. U16a Tunnel, brockhouse transmitting station (on file at DOE Archives and Records Center).



Figure 82. U16a Tunnel Feature 38, cable trough, view northeast (2011).

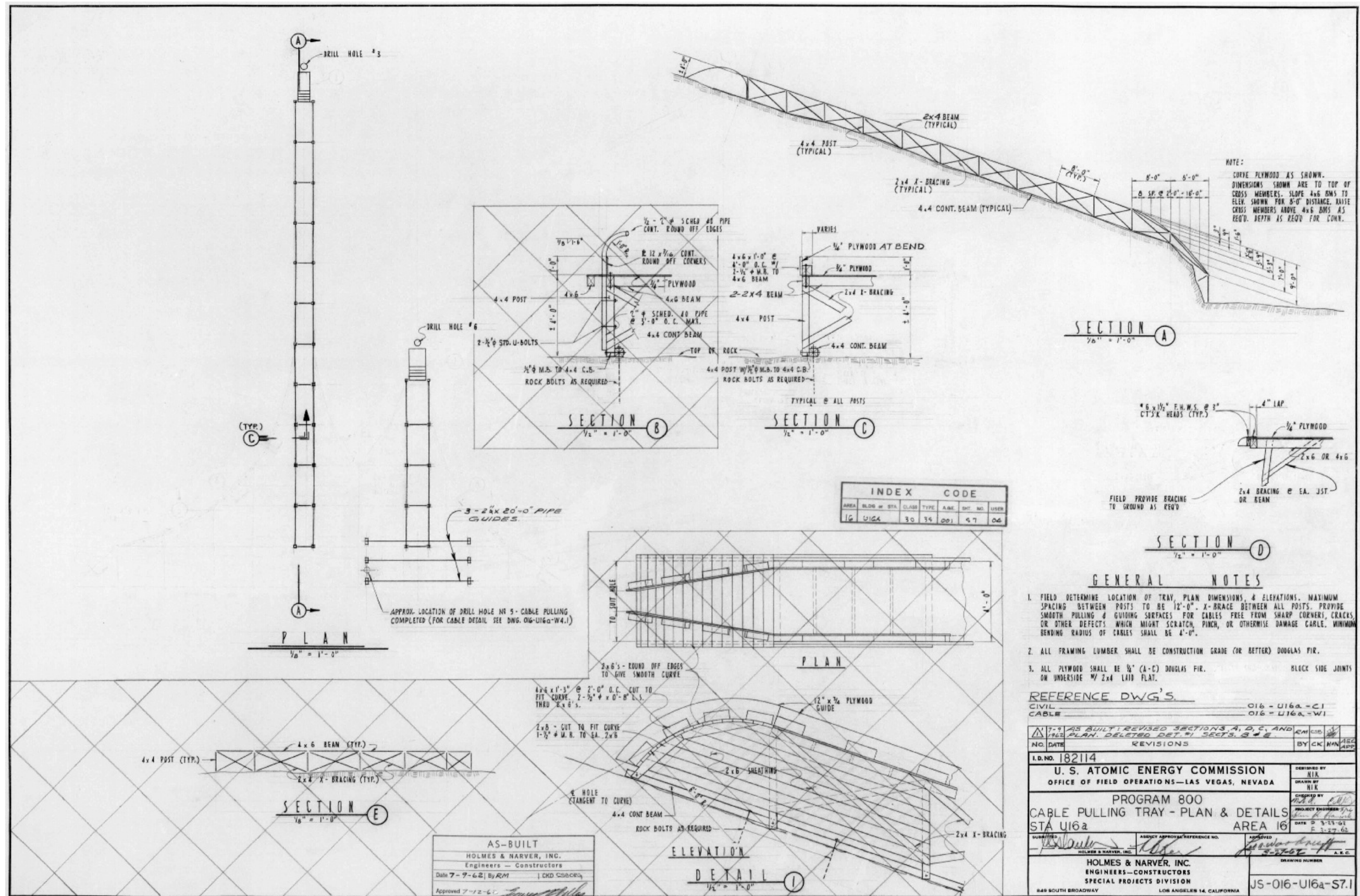


Figure 83. U16a Tunnel Feature 38, cable trough layout (on file at DOE Archives and Records Center).

Feature 39

Feature 39 is the covered instrument trailer park at UTM coordinate 571504 E, 4096232 N and an elevation of 1,670 m. It consists of nine structures for instrument trailers and a covered storage area (Figures 39 and 84). The trailer park is known as Fort Morgan (Flangas and Wyman 2010). The structures are all similar in construction consisting of metal sets, wood lagging, and sand bags and are aligned at 20 degrees. From historic photographs, the instrument trailers were set in place and the structures were constructed over them (Figures 5, 11, and 12). A gap was left between the back of the structures and the bedrock slope and then filled with sand bags. Eventually, the structures were extended (south) to cover the sandbagged bedrock slope. Each structure consists of metal sets that are 4.42 m (174 inches) outside to outside and placed 1.22 m apart (generally). Sets are structural steel members of 15 cm I beam. The lower section is vertical I beam extends approximately 3.05 m and that then curves to form the upper section (half semicircular arch) and extends the member to its maximum height and one half of its total width. These sets are different from sets previously recorded in that they are formed in one piece. The other sets were a vertical section bolted or welded to the curved upper section. Forming the member in one piece and not requiring a mechanical connection would increase its strength. A rectangular metal plate is welded to the end of the curve on each member. Two of the members are bolted together at the plates (top sections form a round or semicircular arch) to form one set. The bottom of the sets are attached to a 10.16 cm piece of channel iron base plate (sometimes covered with soil) that extends the length of the structure. A foam material has been placed between the base plate and the surface. The space between the sets are filled with 2 x 12 inch wood lagging. Except for Structure 1 and Structure 10 the wood lagging begins at 3.05 m above the surface on the north wall, extends over the top of the structure, and ends on the south wall 3.05 m above the surface. For Structure 1, the lagging on the north wall extends to the surface as it does on the south wall of Structure 10. The finished structure resembles a metal and wood tunnel that is 14.3 m (47 ft) in length and 3.73 m in width. Sand bags were placed around the structures and soil was placed over the sand bags and on top of the sets and lagging. The north end of the structure is open to access the trailers and instrument cables. Generally, the structures are similar except for the construction and artifacts at the west end. No trailers remain in the structures.

Structure 1

Structure 1 is constructed similar to the description above (Figure 85). The lagging between the sets on the west wall extends from the surface, over the top of the structure (arch), and ends at 3.05 m above the surface on the east wall. The exposed vertical members of the sets on the east wall are not lagged but braced with horizontal pieces of 10.16 cm angle iron spaced every 0.91 m vertically to prevent racking. On the east wall at 2.7 m above the surface, 20.32 cm angle iron plates are welded to each set. Electrical wires and incandescent lighting are attached to the bottom piece of lagging on the east wall and at approximately 2.74 m on the west wall. Two 76.2 x 50.8 x 17.8 cm electrical panel boxes are attached to the west wall 1 m above the surface and a third panel box is lying on the surface. The arched west end of the structure has been lagged from the top of the sets down to 3.05 m above the surface. At this point, exposed bedrock covered with sand bags closes the south end of the structure. At the west end of the structure along the bedrock and sand bags is a wood platform 1.22 m in width. It extends the width of the structure, through the east wall, and into Structure 2.



Figure 84. U16a Tunnel Feature 39, Fort Morgan, view southwest (2011).



Figure 85. U16a Tunnel Feature 39 Structure 1, view southwest (2011).

Cable access is through the south end of the structure at approximately 3.96 m (13 ft) above the surface near the top of the arch. Cable and the end of the wood cable trough (Feature 38) enters the structure through the lagging in the south end and slopes to the east through the wall into Structure 2. Approximately 30 cables are on the cable trough. Some of the lagging is deteriorated or missing and soil and rocks are entering the structure through the top.

Structure 2

Structure 2 is similar in size and construction to Structure 1 (Figure 86). The west wall of Structure 2 abuts the east wall of Structure 1 (no space between) and the north ends are plumb east-west. The west and east walls contain no lagging from the surface up to 3.05 m. On each wall at 2.7 m above the surface, 20.32 cm angle iron plates are welded to each set. Electrical wires and incandescent lighting are attached to the bottom piece of lagging on each wall. The arched south end of the structure has been lagged from the top of the sets down to 3.05 m above the surface. At this point, exposed bedrock covered with sand bags closes the south end of the structure. However, the top two pieces of lagging have pulled away from the sets allowing soil placed on top of the structure to enter and cover part of the exposed bedrock, sand bags, and part of the wood platform. The wood platform from Structure 1 extends between the open sets into Structure 2. It is 1.22 m in width and extends the width of the structure along the south wall. Above the platform in the southwest corner of the structure, plywood from the cable trough from Structure 1 enters Structure 2 at 3.05 m above the surface on the north wall. All of the insulated cables on the cable trough have been cut flush at the north wall of Structure 2. In front of the platform is a 1.22 x 1.22 m plywood backboard to which insulated cables, similar to those on the cable trough, have been attached.

Structure 3

Structure 3 is similar in size and construction to the previous structures (Figure 87). The west wall of Structure 3 abuts the east wall of Structure 2 (no space between) and the north ends are plumb east-west. The west and east walls contain no lagging from the surface up to 3.05 m. The south end of the structure was constructed similar to the previous ones with lagging down to exposed bedrock. In addition to the end wall, a second wall was constructed at 3.7 m from the south end (fourth set). The bottom wall is constructed in two sections. The bottom section consists of three vertical I beams, spaced at 3 ft intervals, that extend from the surface up to 3.05 m. A horizontal I beam (header) was placed across the top vertical pieces. The top section consists of two I beams placed vertically on top of the horizontal I beam and extending to the arch of the fourth set. On the bottom section, wood lagging was placed between the vertical I beams and sand bags were placed on the east side of the wall. At least one half of the lagging in the arched section of the second wall has been removed or was never installed. Also, the south section of the roof between the south and second wall is missing as is most of the back wall lagging. This has allowed soil from the outside to slough off into the structure and cover all of the space between the south wall and the second wall and the sand bags and wood platform along the second walls lower section. Insulated cables enter the second wall below the horizontal I beam at the west end. The modification to the south end of the structure may have been due to the drilling of the U16a CH#6 cable hole that is located directly behind Structure 3 and the insulated cables may be from this cable hole.



Figure 86. U16a Tunnel Feature 39 Structure 2, view southwest (2011).



Figure 87. U16a Tunnel Feature 39 Structure 3, view southwest (2011).

Structure 4

Structure 4 is similar in size and construction to structures 1-3 (Figure 88). The west wall of Structure 4 is offset 25.4 cm from the east wall of Structure 3 and the north ends are plumb east-west. The west and east walls contain no lagging from the surface up to 3.05 m. Three 200 amp switch boxes are mounted between sets 7 and 8 (from the south) on the west wall. Each switch box measures 66.04 x 33.02 x 12.7 cm (26 x 13 x 5 inches) and has insulated black cable extends from the bottom of the box into the subsurface. The arched south end of the structure has been lagged from the top of the sets down to 3.05 m above the surface. At this point, exposed bedrock covered with sand bags closes the south end of the structure. The wood platform found in the previous structures extends along the south end between the west and east walls. Approximately 40 insulated cables extend through the west wall from Structure 3 along the wood platform. An additional 20 insulated cables enter the structure from approximately 2.44 m above the wood platform through the west wall and joins the cables on the platform. A 1.83 x 1.22 plywood backboard is along the front edge of the wood platform. Attached to the backboard are nine various sized insulated cables that extend onto the wood platform and into Structure 5. A large pile of soil has been placed inside the entrance of the structure.

Structure 5

Structure 5 is similar in size and construction to the previous structures (Figure 89). The west wall of Structure 5 is offset 16.51 cm from the east wall Structure 4 and the north ends are plumb east-west. The west and east walls contain no lagging from the surface up to 3.05 m. The south end of the structure was constructed similar to the previous ones with lagging down to exposed bedrock. Sand bags have been placed on the exposed bedrock at the south end. The wood platform found in the previous structures extends along the south end between the west and east walls. Approximately 100 insulated cables extend through the west wall from Structure 4, along the wood platform, and exit through the east wall into Structure 6. Approximately 40 cables from the wood platform have been ganged together, looped around a set in the west wall, and attached to a wood rack attached to the seventh set (from south). These were probably attached to the instrument trailer that has been removed from the structure. A large pile of soil has been placed inside the entrance of the structure.

Structure 6

Structure 6 is similar in size and construction to the previous structures (Figure 90). The west wall of Structure 6 is offset 12.7 cm from the east wall of Structure 5 and the north end of Structure 6 is set back to the south 132.08 cm (52 inches) from the north end of Structure 5. The west and east walls contain no lagging from the surface up to 3.05 m. An electrical switch box is mounted to a 1.22 x 1.22 m plywood backboard on the west wall at set 6 (from north end). The switch box measures 99.06 x 50.8 x 20.32 cm (39 x 20 x 8 inches). A 1.83 x 1.38 m (72 x 55 inch) metal electrical panel backboard is mounted to the west wall between sets 7 and 8 (from north end). Attached to the backboard is one 60 amp, one 30 amp, and three 200 amp switch boxes. There are no angle iron plates welded to the sets as in the other structures. The south end of the structure was constructed similar to the previous ones with lagging down to exposed bedrock. Sand bags have been placed on the exposed bedrock at the south end. The wood platform found in the previous structures extends



Figure 88. U16a Tunnel Feature 39 Structure 4, view southwest (2011).



Figure 89. U16a Tunnel Feature 39 Structure 5, view southwest (2011).



Figure 90. U16a Tunnel Feature 39 Structure 6, view southwest (2011).

along the south end between the west and east walls. Approximately 100 insulated cables extend through the east wall from Structure 5, along the wood platform, and exit through the east wall into Structure 7. Also, a cable trough enters the structure at the high point of the arch at the south end and extends down the sloping bedrock to the wood platform. There are more than 50 cables on the trough that join with the cables on the wood platform. Approximately 30 cables on the wood platform have been ganged and looped back to set 8 (from south) on the west wall. Approximately 25 cables have been ganged together from the wood platform and looped back to set 7 (from south) on the east wall. These were probably attached to the instrument trailer that has been removed from the structure. A large pile of soil has been placed inside the entrance of the structure. Associated artifacts in the structure are rolls of cable, plywood, a 1.1 m (42 inch) diameter metal vent, a 1.11 x 1.11 x 0.28 m (44 x 44 x 11) plywood box, and plywood fragments buried in the soil pile.

Structure 7

Structure 7 is similar in size and construction to the previous structures (Figure 91). The west wall of Structure 7 is offset 22.86 cm from the east wall of Structure 6 and the north end of Structure 7 is set back to the south 1.52 m from the north end of Structure 6. The west and east walls contain no lagging from the surface up to 3.05 m. There are no angle iron plates welded to the sets. The wood platform found in the previous structures extends along the south end between the west and east walls and contains approximately 30 cables. The roof at the south end has collapsed on the west side between the first two sets and the arched end section is missing. Rocks and soil have sloughed onto the wood platform. A large pile of soil has been placed inside the entrance of the structure.

Structure 8

Structure 8 is similar in size and construction to the previous structures (Figure 92). The west wall of Structure 8 is offset 17.78 cm from the east wall of Structure 7 and the north end of Structure 8 is set back to the south 1.22 m from the north end of Structure 7. The west and east walls contain no lagging from the surface up to 3.05 m. There are no angle iron plates welded to the sets. The wood platform found in the previous structures that extends along the south end between the west and east walls is not visible as rocks and soil have sloughed off of the roof and covers the bedrock, sandbags, and platform. This is due to missing lagging on the west side of the arched section at the south end between sets 1 and 3. A horizontal I beam has been set at 30.5 m above the surface between the west and east walls at set 5 (from south). Two I beams were placed vertically on top of the horizontal I beam and extend to the top of the arched section (similar to Structure 3).

Structure 9

Structure 9 is similar in size and construction to the previous structures (Figure 93). The west wall of Structure 9 is offset 22.86 cm from the east wall of Structure 8 and the north end of Structure 9 is set back to the south 2.44 m from the north end of Structure 8. The west and east walls contain no lagging from the surface up to 3.05 m. A 3.35 x 1.42 m electrical panel backboard is near the west wall between sets 6 and 9 (from north). Attached to the backboard are four 200 amp switch boxes, three 60 amp switch boxes, and one 100 amp switch box. At the south end, additional 6 x 8 inch milled lumber extends from the surface at set 2 on the east wall to set 3 on the west wall. This helps support the roof and acts as shoring to control the loose soil at the south end. A partial wall has been



Figure 91. U16a Tunnel Feature 39 Structure 7, view southwest (2011).



Figure 92. U16a Tunnel Feature 39 Structure 8, view southwest (2011).



Figure 93. U16a Tunnel Feature 39 Structure 9, view southwest (2010).

constructed from set 7 on the west wall to set 4 on the east wall. Wood bracing extends from the surface to approximately 1 m at the base of the wall. On top of the bracing is a horizontal I beam that extends from set 7 to set 4. Two vertical I beams extend from the horizontal beam to the arch section of sets 3 and 4. Wood lagging has been added to form a partial wall that extends 4.88 m (16 ft) from the west wall and is 2.44 m in height. The area behind the wall and at the shoring have been sand bagged along the west wall. The modifications may be the result of the drilling of U16a CH#5 cable hole, that is located at the back of Structure 9. Associated artifacts are lagging, I beam, cable, and a 1.07 x 1.07 x 0.61 m plywood box. Mounted to the outside of the first set at the top of the arch is a 45.72 cm diameter light fixture.

Structure 10

Structure 10 is similar in construction to the previous structures but consists of a 18.23 m (60 ft) long structure with a wood entry and is completely covered with soil (Figure 94). It is not open ended as are the other structures. The west wall of Structure 10 is offset 22.86 cm from the east wall of Structure 9 and the north end of Structure 10 is set back to the south 2.44 m from the north end of Structure 8. Lagging extends from the surface on the east wall, continues over arched the top, and ends at 3.05 m above the surface on the west wall. The south end of the structure is filled with soil and rock that have sloughed off of the roof through areas where the lagging is missing and through the wall from Structure 9. The structure has been placed on 4 x 6 inch milled lumber joists spaced at each set. Partial flooring has been installed near the north entrance with 3/4 inch plywood and 3 x 12 inch milled lumber along the west side of the metal containers. On the south wall, 3 x 12 inch wood lagging extends 3.05 m to bottom of the arched top. A 0.91 x 1.73 m opening cut into the lagging provides access to the entry way in the north end of the structure. The entry is a double L in shape. It extends 2.84 m (112 inches) north, turns west for 4.88 m (192 inches), and then turns north for 2.84 m (Figure 95). The entry way is constructed of 6 x 8 inch milled lumber studs and 2 x 12 inch milled lumber for the walls and ceiling. The floor is 3/4 inch plywood that is held 30.5 cm above the surface. Along the north wall is a 0.91 x 0.91 x 0.91 plywood table with 2 x 4 inch legs. On sets 6 and 7 (from north) are two 30 amp switch boxes. A storage area is to the south of the entry way and contains two metal containers (Figure 96). The first metal container is 3.35 m south of the north wall (entry way). It measures 2.36 x 1.83 x 1.83 m (93 x 76 x 76 inches). It is labeled DRAVO TRANSPORTAINER and was manufactured in Pittsburgh, PA. It originally contained two doors 0.91 m in width. Only the north door remains as the south door has been covered with a thin metal sheet forming a wall. Inside the container are shelves on the west wall and a 30.48 x 193.04 cm rack in the center. The second metal container is of the same manufacturer and size as the first. The north door remains and the south door has been covered with plywood and metal forming a wall. On the north and west walls are three shelves.

Feature 40

Feature 40 is a buried barrel at UTM coordinate 571512 E, 4096339 N and an elevation of 1,689 m. The barrel is 61 cm in diameter and extends 15.24 cm above the surface (Figures 39 and 97). The bottom of the barrel is filled with concrete leaving 61 cm of empty space in the barrel. The top of the barrel is sealed with a metal lid. A 1.07 m metal T post is along the northwest side of the barrel. Associated artifacts are communication wire and insulated cable.



Figure 94. U16a Tunnel Feature 39 Structure 10, view northwest (2010).



Figure 95. U16a Tunnel Feature 39 Structure 10, entry, view southwest (2011).



Figure 96. U16a Tunnel Feature 39 Structure 10, containers, view southwest (2011).



Figure 97. U16a Tunnel Feature 40, barrel, view north (2011).

Feature 41

Feature 41 is a metal tower at UTM coordinate 571575 E, 4096448 N and an elevation of 1,667 m. The tower consists of a 5.04 cm pipe that is 6.4 m in height (Figures 39 and 98). It has 14 steps made from rebar bent to form triangles welded to opposite sides of the pipe. The tower is supported by two guy wires attached to rebar stanchions and one tied to a juniper tree.

Feature 42

Feature 42 is the U16a #1 vent at UTM coordinate 571339 E, 4096113 N and an elevation of 1,779 m (5,835 ft). It consists of a vent pipe, adapter box, and blower assembly (Figures 39 and 99). The pipe extends above the surface approximately 30.48 cm. Two metal I beams lying on the surface are welded to opposite sides of the pipe. The vent pipe enters the rectangular metal adapter box from the bottom. The box has an opening of the north side for attachment of the blower and a hinged cover plate on the top to access the box. The blower assembly is cylindrical with an aluminum impeller that is driven by an electric motor. One end of the blower has a flange for attachment to the metal box and the other end is open and secured with wire mesh. An electrical switch box is mounted to the top of the blower. The blower is supported by foam insulation within a semicircular metal plate (cradle). The semicircular plate is attached to a horizontal metal plate with coil springs to dampen vibrations. No measurements were taken as the feature is within a contamination area.

Feature 43

Feature 43 is the U16a.04 PS #1V drill hole at UTM coordinate 570602 E, 4096053 N and an elevation of 1,961 m (6,435 ft). It consists of a piece of 20.32 cm diameter pipe extending 22.86 cm above the surface that is filled with concrete (Figures 39 and 100). A metal plate with U16a-04-PSIV is welded to the side of the pipe. A metal T post is approximately 30.5 cm from the pipe.

Feature 44

Feature 44 is the UE16a #1 drill hole at UTM coordinate 570914 E, 4095912 N and an elevation of 2,010 m (6,595 ft). It consists of a concrete pad with a 20.32 diameter hole (Figures 39 and 101). A 30.5 x 30.5 cm piece of plywood is near the concrete and is probably used to cover the hole.

Feature 45

Feature 45 is the U16a.03 PS #1A and PS #1AS drill hole at UTM coordinate 570914 E, 4096115 N and an elevation of 1,951 m (6,402 ft). It consists of a 2.74 m diameter corrugated metal cellar filled with sand (Figures 39 and 1012). Four metal T posts form a rectangle around the metal cellar.

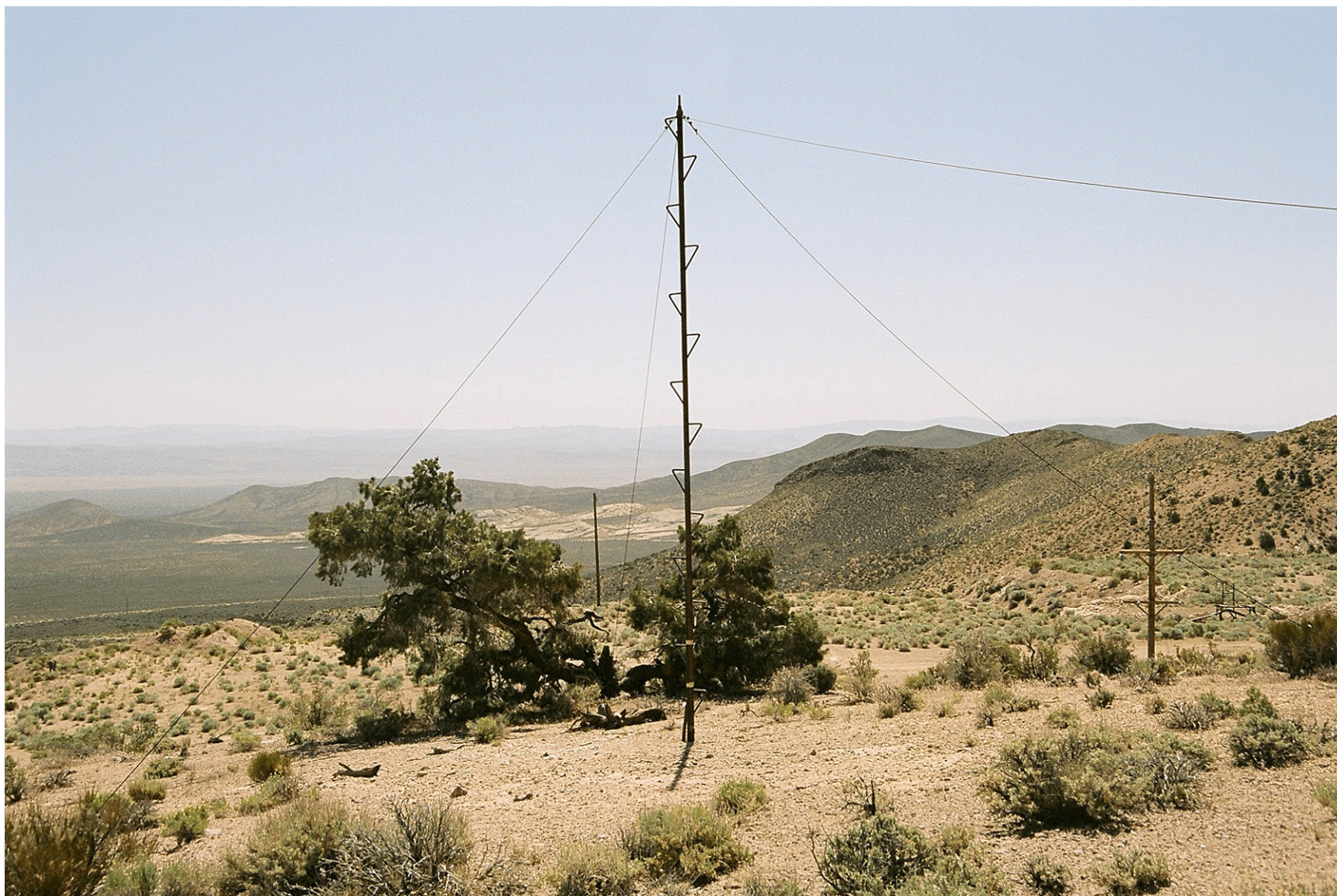


Figure 98. U16a Tunnel Feature 41, tower, view east (2011).



Figure 99. U16a Tunnel Feature 42, U16a #1 vent and blower assembly, view east (2011).



Figure 100. U16a Tunnel Feature 43, U16a.04 PS #IV drill hole, view east (2011).



Figure 101. U16a Tunnel Feature 44, UE16a #1 drill hole, view southeast (2011).



Figure 102. U16a Tunnel Feature 45, U16a.03 PS #1A and PS #1AS drill hole, view southeast (2011).

Feature 46

Feature 46 is the U16a PS #2 W/S drill hole at UTM coordinate 571035 E, 4096016 N and an elevation of 1,961 m (6,443 ft). It consists of a piece of 30.48 diameter pipe that extends 21.59 cm (8.5 inches) above the surface (Figures 39 and 103) . The pipe is sealed with a metal plate welded to the flanged end of the pipe. On the plate is READY WS-1 that has been ground into the metal. Protruding through the side is a piece of 15.24 cm pipe that is sealed with a welded metal cap.

Feature 47

Feature 47 is the U16a PS#1 drill hole at UTM coordinate 571082 E, 4095978 N and an elevation of 1,962 m (6,437 ft). It consists of a 45.7 x 45.7 (18 x 18 inch) rectangular piece of rough poured concrete with a 22.86 cm diameter hole (Figures 39 and 104). The hole was for pipe that extended above the surface that has since been removed. The abandoned drill hole is approximately 2.4 m south of U16a #1 water sampling well.



Figure 103. U16a Tunnel Feature 46, U16a PS #2 W/S drill hole, view southeast (2011).



Figure 104. U16a Tunnel Feature 47 U16a PS#1 drill hole, view southeast (2011).

SUMMARY AND RECOMMENDATIONS

The U16a Tunnel is near the base of Shoshone Mountain in Area 16 of the NNSS in southern Nye County, Nevada. It was one of a series of tunnels mined specifically for underground nuclear tests. U16a Tunnel provided a testing arena where military weapons systems, e.g., missiles or satellites, could be exposed and evaluated under actual conditions of a nuclear explosion. However, unlike previous tunnels, it was also used for extensive high explosives testing.

Construction of the tunnel began in 1962 shortly after the testing moratorium ended between the United States and the former Soviet Union. The first test, Marshmallow, was originally scheduled to occur in the U12e.01 drift at the U12e Tunnel in Area 12. However, the test was moved to Area 16 because the predicted seismic activity resulting from future scheduled testing required a relatively quiet area. The first three tests in U16a Tunnel were joint DoD and LLNL and the last three were DoD and LASL. The first four tests utilized a line-of-sight pipe in which the nuclear device was placed in an A-box attached to the small tapered end of the line-of-sight pipe. The last two tests were cavity tests. All of the tests were conducted individually. The overall objective of the nuclear tests was weapons effects of a nuclear detonation on equipment and material with some at a simulated high altitude. Most of the high explosives testing was a part of DTRA's effort to detect, neutralize, and assess the damage inflicted to underground structures. The nuclear tests were conducted between 1962 and 1971. High explosives testing continued until 2001.

Modifications to the landscape surrounding the U16a Tunnel have resulted from road construction and maintenance, mining activities related to development of the tunnel, site preparation for activities related to experiments and testing at the tunnel. The U16a Tunnel complex encompasses 41.1 acres (16.7 hectares) with 19.2 acres (7.77 hectares) for the portal area and 21.9 acres (8.9 hectares) for the top of Shoshone Mountain. Forty-seven cultural features, 41 at the portal area and 6 on Shoshone Mountain, were described, mapped, and photographed. At the U16a portal area, features relate to the construction, testing, general everyday support of activities within the tunnel, and high explosives testing. These include concrete foundations for buildings, rail lines, a power system, and mining equipment. Features on Shoshone Mountain relate to post-shot drilling and the tunnel ventilation system.

NATIONAL REGISTER ELIGIBILITY RECOMMENDATION

Nuclear testing is one of the study units stated in the Nevada Comprehensive Preservation Plan provided by the Nevada State Historic Preservation Office (White et al. 1991). Accordingly, the major sites and structures associated with nuclear testing are considered to have intrinsic significance in the history of Nevada and the nation and are eligible to the National Register of Historic Places. The U16a Tunnel used from 1962 to 1971 for underground nuclear tests by DTRA, LLNL, and LANL is eligible to the National Register of Historic Places under criteria a and c, consideration g of 36 CFR Part 60.4 as a historic landscape. Consideration g refers to those cultural resources achieving significance within the past 50 years if they are of exceptional importance. It does not qualify under criteria b and d.

Criterion a refers to events that have made significant contributions to the broad patterns of our history. Research at the U16a Tunnel was conducted in the defense of the United States during the

Cold War, a war characterized by competing social, economic, and political ideologies between two superpowers - the former Soviet Union and the United States. Atomic weaponry was central to this ongoing struggle in order to gain military advantage and deter aggression from the other side. The purpose of the U16a Tunnel was to provide an underground testing environment for the development of nuclear weapons and to assess the effects of a nuclear explosion on materials and equipment.

Criterion b applies to properties associated with individuals whose specific contributions to history can be identified and documented. No such person has been identified with the U16a Tunnel.

Criterion c applies to properties significant for their physical design or construction, including architecture, landscape architecture, and engineering. The U16a Tunnel embodies a distinctive characteristics of a type and method of construction and engineering for conducting underground nuclear tests. It also provided a context for innovating and improving on the containment and costs of such tests by way of engineering and technology.

Criterion d refers to important research questions about human history or prehistory that can only be answered by the actual physical material of a cultural resource. The U16a Tunnel does not meet this criterion.

MANAGEMENT RECOMMENDATIONS

As a historic landscape eligible to the National Register of Historic Places, the DRI recommends that the U16a Tunnel area be left in place in its current condition. It is also recommended that the U16a Tunnel historic landscape be included in the NNSS monitoring program and monitored for disturbances or alterations on a regular basis.

REFERENCES

Anders, Roger M.

- 1978 *Institutional Origins of the Department of Energy*. Energy History Series 1(1), The Office of Military Application, U.S. Department of Energy, Washington, D.C.

Babcock, Sue and Jim Rocco

- 2000 *Dipole Hail 24 Results Report*. Defense Threat Reduction Agency, Kirtland AFB, New Mexico.

Bennett, Max

- 1991 *Drilling and Mining Summary, through December 1990*. Raytheon Services Nevada, Mercury, Nevada (OUO).

Brackett, A.O.

- 1972 *Stemming Mechanics Study Nitromethane Calibration Shot U16a.05 Mine Dust*. EG&G Inc., Albuquerque, New Mexico.

Brady, William J., Karen K. Horton, and Bernard F. Eubank

- 1984 *Operations Nougat and Whetstone Events Hard Hat, Danny Boy, Marshmallow, Mudpack, Wishbone, Gumdrop, Diluted Waters, and Tiny Tot 15 February 1962-17 June 1965*. Field Command, Defense Nuclear Agency, Kirtland Air Force Base, New Mexico.

Brady, William J., Bernard Eubank, Elizabeth McDowell, and Joe A. Stinson

- 1989 *Operations Anvil, Cresset, Tinderbox, and Guardian: Events Husky Pup, Mighty Epic, Hybla Gold, Diablo Hawk, Huron King, and Miners Iron, 24 October 1975 - 31 October 1980*. Report DNA 6325F, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, New Mexico.

Brown, Brisbane H.

- 1970 *Operation Mighty Mite Shot Diamond Dust Project Officers Report*. Test Command, Sandia Base, Albuquerque, New Mexico.

Buck, Alice L.

- 1983 *A History of the Atomic Energy Commission*. Report DOE/ES-0003/1, U.S. Department of Energy, Washington, D.C.

Carothers, James

- 1995 *Caging the Dragon: The Containment of Underground Nuclear Explosions*. Report DOE/NV 388, Nevada Operations Office, Department of Energy, Las Vegas, Nevada.

Carter, Michael, Jeff Duray, James Fryling, Fritz Rossler, and Pete Thompson

- 1995 *FY 95 High Explosive Tests Program Document Addendum*. Field Command, Defense Nuclear Agency Test Operation Directorate, Kirtland Air Force Base, New Mexico.

Castetter, R.C. and H.O. Hill

1979 Additions to the Birds of the Nevada Test Site. *Western Birds* 10:221-223.

Coye, Vincent

1970 *Minute Gun Series Shot Ming Vase: Project Officers Report— Project 9.62, Stemming and Containment Dynamics*. Underground Dynamics Department Poulter Laboratory for High Pressure Research, Stanford Research Institute, Menlo Park, California.

Davis, R.E. and D.L. Hoover

1962 *Appraisal of Proposed New Ground Zero Location Near U16a Site, Area 16, Nevada Test Site*. Technical Letter: Marshmallow-6. U.S. Department of the Interior Geological Survey, Denver, Colorado.

Davis Robert E. and Richard P. Snyder

1962 *Preliminary Report on the Extent and Character of Explosion-Induced Fractures, Area 16, Nevada Test Site*. U.S. Department of the Interior, Geological Survey, Denver, Colorado.

Davis, R.E. and Snyder, R.P.

1962 Preliminary report on the extent and character of explosion-induced fractures, Area 16, Nevada Test Site. U.S. Geological Survey Technical Letter: Marshmallow-5, 6 p.

Davis, Walter J.

1972 *Mighty Mite Series Diamond Mine Event Test Group Directors Final Summary Report*. Test Command, Kirtland Air Force Base, New Mexico.

Defense Atomic Support Agency (DASA)

1964 *Operations Nougat and Sun Beam: Organizational, Operational, Funding, and Logistic Summary*. Field Command, Defense Atomic Support Agency, Sandia Base, New Mexico.

Defense Threat Reduction Agency (DTRA)

2002 *Defense's Nuclear Agency 1947-1997*. Defense Threat Reduction Agency, U.S. Department of Defense, Washington, D.C.

Department of Energy (DOE)

1997 *Linking Legacies: Connecting the Cold War Nuclear Weapons Production Processes to their Environmental Consequences*. Report DOE/EM-0319, Office of Environmental Management, U.S. Department of Energy, Washington, D.C.

Department of Energy, National Nuclear Security Administration Nevada Site Office (DOE/NNSA)

2004 *Corrective Action Investigation Plan for Corrective Action Unit 99: Rainier Mesa/Shoshone Mountain, Nevada Test Site, Nevada*. Report DOE/NVO-1031, U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, Las Vegas, Nevada.

Department of Energy, Nevada Operations Office (DOE/NV)

- 2000 *United States Nuclear Tests: July 1945 through September 1992*. Report DOE/NV-209 (Revision 15), U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.

Directorate of Test Operations

- 1970 *Test Plan Diamond Mine*. Test Command Defense Atomic Support Agency, Albuquerque, New Mexico.

Dohrenwend, John C.

- 1987 Basin and Range. In *Geomorphic Systems of North America*, edited by W.L. Graf, pp. 303-342. Centennial Special Volume 2, Geological Society of America, Boulder, Colorado.

Drollinger, Harold, Colleen M. Beck, and Nancy Goldenberg

- 2003 *Historical Evaluations of Control Point Buildings 2, 10, 43, and 400 in Area 6, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR071602-1, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold and Nancy Goldenberg

- 2004 *An Historical Evaluation of the Super Kukla Control Building, Area 27, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR042104-3, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Thomas F. Bullard, Laurence J. Ashbaugh, and Wayne R. Griffin

- 2007 *A Historical Evaluation of the U12e Tunnel, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 104, Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Nancy Goldenberg, and Colleen M. Beck

- 2000 *An Historical Evaluation of the Super Kukla Facility in Area 27 for Activities Associated with the Decontamination and Decommissioning Program, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR021700-1, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Nancy Goldenberg, and Carin Petersen

- 2005 *An Historical Evaluation of the Pluto Control Facility, Area 26, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. HE041305-1, Desert Research Institute, Las Vegas, Nevada.

Drollinger, Harold, Robert C. Jones, Thomas F. Bullard, Laurence J. Ashbaugh, and Wayne R. Griffin

- 2009 *A Historical Evaluation of the U12t Tunnel, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 105, Desert Research Institute, Las Vegas, Nevada.

- 2010 *A Historical Evaluation of the U12n Tunnel, Nevada National Security Site, Nye County, Nevada*. Cultural Resources Technical Report No. 106, Desert Research Institute, Las Vegas, Nevada.
- Edwards, Donald H.
- 1967 Memorandum: USPHS Engineering Development Program Report - Double Play. U.S. Public Health Service, Nevada.
- Edwards, Susan R.
- 1997 *Atomic Age Training Camp: The Historical Archaeology of Camp Desert Rock*. M.A. thesis, Department of Anthropology and Ethnic Studies, University of Nevada, Las Vegas.
- Edwards, Susan R. and William G. Johnson
- 1995 *A Historical Evaluation of Building 2-300, Yucca Flat, Area 2, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR062095-2, Desert Research Institute, Las Vegas, Nevada.
- Flangas, William G.
- 2009 *U12n Tunnel Interview*. Video disk on file, Desert Research Institute, Las Vegas, Nevada.
- Flangas, William G. and Richard Wyman
- 2010 *U12t Tunnel Interview*. Video disk on file, Desert Research Institute, Las Vegas, Nevada.
- Friesen, H.N.
- 1995 *A Perspective on Atmospheric Nuclear Tests in Nevada: Fact Book*. Report No. DOE/NV 296, U.S. Department of Energy, Nevada Operations Office, Las Vegas, Nevada.
- Frizzell, V.A. Jr., and Schulters, J.
- 1990 Geologic map of the Nevada Test Site, southern Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I-2046, scale 1:100,000.
- Garbin, Douglas H.
- 1999 *Analysis of Mining Activities Post-Dipole Hail 2, 3, 6 and 8*. Sandia National Laboratories, Albuquerque, New Mexico.
- Greger, Paul D.
- 1994 Status of Horses, Deer, and Birds on the Nevada Test Site in 1993. In *Status of the Flora and Fauna on the Nevada Test Site, 1993*, pp. 124-137, Report DOE/NV/11432-162, Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada.

Horton, Karen K., Bernard F. Eubank, and William J. Brady

- 1985 Operations Crosstie and Bowline Events Door Mist, Dorsal Fin, Milk Shake, Diana Moon, Hudson Seal, and Ming Vase, 31 August 1967 - 20 November 1968. Report DNA 6322F, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, Albuquerque.
- 1987 *Operations Mandrel and Grommet: Events Minute Steak, Diesel Train, Diana Mist, Mint Leaf, Hudson Moon, Diagonal Line, and Misty North, 12 September 1969 to 2 May 1972*. Report DNA 6323F, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, Albuquerque.

Hunt, Dea A.

- 2001 *Summary of DTRA High Explosive Events, August 1988-September 1998*. ITT Industries Advanced Engineering & Sciences, Inc/DTRIAC. Kirtland Air Force Base, New Mexico.

Johnson, Gerald W., Gary H. Higgins, and Charles E. Violet

- 1959 *Underground Nuclear Detonations*. Report UCRL-5626, Lawrence Radiation Laboratory, University of California, Livermore.

Johnson, William G.

- 1994 *A Historical Evaluation of the Area 2 Equipment Support Yard, Yucca Flat, Area 2, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR020894-1, Desert Research Institute, Las Vegas, Nevada.
- 2002 *A Historical Evaluation of the T-3b Fizeau Bunker, Area 3, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR082201-1, Desert Research Institute, Las Vegas, Nevada.

Johnson, William G. and Susan R. Edwards

- 1996 *Historic American Buildings Survey Documentation of the Japanese Village on the Nevada Test Site*. Historic American Building Survey No. NV-27, U.S. National Park Service, Washington, D.C.
- 2000 *Survival Town: The Apple-2 Historic District, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 99, Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, Nevada.

Johnson, William G., Barbara A. Holz, and Robert Jones

- 2000 *A Cold War Battlefield: Frenchman Flat Historic District, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 97, Division of Earth and Ecosystem Sciences, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C.

- 2003 *Historical Evaluation of Kay Blockhouse, Frenchman Flat, Area 5, Nevada Test Site, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report No. SR030703-1, Desert Research Institute, Las Vegas, Nevada.
- 2004 *A Historical Evaluation of Station 7-800 in Area 7, Nevada Test Site, Nye County, Nevada*. Historical Evaluation Short Report HE042004-1, Desert Research Institute, Las Vegas, Nevada.
- 2005 *An Inventory of Benches at Viewing Points for Atmospheric Nuclear Testing Events at the Nevada Test Site, Nye County, Nevada*. Cultural Resources Inventory Report SR020904-1, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C., Thomas F. Bullard, and Colleen M. Beck

- 2006 *Historical Evaluation of U12b Tunnel Complex in Area 12, Nevada Test Site, Nye County, Nevada*. Desert Research Institute Historical Evaluation Report No. HE0106-1, Las Vegas, Nevada.

Jones, Robert C., Colleen M. Beck, and Barbara A. Holz

- 2005 *Yucca Lake Historic District, Area 6, Nevada Test Site, Nye County, Nevada*. Cultural Resources Technical Report No. 102, Desert Research Institute, Las Vegas, Nevada.

Jones, Robert C. and Harold Drollinger

- 2001 *A Class III Cultural Resources Reconnaissance of the Proposed Underground Test Area Seismic Lines in Frenchman Flat, Nevada Test Site, Areas 5 and 11, and Nellis Air Force Range, Nye County, Nevada*. Cultural Resources Reconnaissance Short Report SR060401-1, Desert Research Institute, Las Vegas, Nevada.

Kingsley, W. H., L.W. Brewer, W.D. Burnett, D.J. Coleman, H.L. Rarrick

- 1966 *Operation Whet Stone Shot Gum Drop: Project Officers Report—Project 45.6, Re-Entry Safety*. Sandia Corporation, Albuquerque, New Mexico.

Kratz, Howard R. and Bruce A. Hartenbaum

- 1972 *Mighty Mite Series Diamond Mine Event: Project Officers Report, Calibration Shot Ground Motion Measurements*. Defense Nuclear Agency, Washington, D.C.

LaComb, Joseph W., Margaret J. Townsend, Sheldon, D. Murphy, Barry M. Pritchett, Byron L. Ristvet, Stewart A. Thomas, and James H. Metcalf

- 1996 *E-Tunnel Discharge Elimination Review Committee: Final Report*. Defense Nuclear Agency, Nevada Operations Office, Mercury, Nevada.

Lawrence Radiation Laboratory (LRL)

- 1961 *General Re-Entry Procedure for Underground Nuclear Events*. Report CN-294 Lawrence Radiation Laboratory, University of California, Livermore.

Lay, James S., Jr.

- 1950 *Memorandum for the President from the National Security Council, December 18, 1950.* Manuscript on file, Accession No. 304388, Nuclear Testing Archive, U.S. Department of Energy, Nevada Site Office, Las Vegas.

Loeber, Charles R.

- 2002 *Building the Bombs: A History of the Nuclear Weapons Complex.* Sandia National Laboratories, Albuquerque, New Mexico.

Malik, J.S., R.R. Brownlee, C.F. Costa, H.F. Mueller, and R.W. Newman

- 1981 *Radiological Criteria for Underground Nuclear Tests.* Report LA-8776-MS, Los Alamos Scientific Laboratory, New Mexico.

McMullan, Frank W.

- 2004 *Summary of High Explosive Events August 19998-September 2003.* ITT Industries, DTRIAC, Kirtland Air Force Base, New Mexico.

Medica, P.A.

- 1990 Noteworthy Mammal Distribution Records for the Nevada Test Site. *Great Basin Naturalist* 50(1):83-84.

Mullen, Omer W. and Bernard F. Eubank

- 1977 *Operation Anvil Onsite Radiological Safety Report, July 1975 through September 1976.* Report NVO-410-41, Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada.

National Security Technologies, LLC (NSTec)

- 2009 *Facility Closure Report for Tunnel U16a, Area 16, Nevada Test Site, Nevada.* National Security Technologies, LLC, Las Vegas, Nevada.

Ogle, William E.

- 1985 *An Account of the Return to Nuclear Weapons Testing by the United States after the Test Moratorium 1958-1961.* U.S. Department of Energy, Nevada Operations Office, Las Vegas. (Redacted version).

O'Farrell, Thomas P. and LaVerne A. Emery

- 1976 *Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography.* U.S. Energy Research and Development Administration, Technical Information Service, Springfield, Virginia.

Orkild, P.P.

- 1963 Geologic map of the Tippipah Spring Quadrangle, Nye County, Nevada: U.S. Geological Survey Geologic Quadrangle Map GQ-213, scale 1:24,000.

- Ostler, W. Kent, Dennis J. Hansen, David C. Anderson, and Derek B. Hall
2000 *Classification of Vegetation on the Nevada Test Site*. Bechtel Nevada Ecological Services, Las Vegas, Nevada.
- Peterson, F.F.
1988 Appendix B, Consultant's Report: Soil-Geomorphology Studies in the Crater Flat, Nevada Area. In *Quaternary Geology and Active Faulting at and near Yucca Mountain*, edited by Bell, J.W., Nevada Bureau of Mines and Geology, Reno.
- Reeves, R.B.
1963 *Operation Nougat Shot Marshmallow: Marshmallow Vacuum System Vulnerability Study*. Field Command Defense Atomic Support Agency, Sandia Base, New Mexico.
- Rinehart, Eric
1998 *FY 98 High Explosive Tests Program Document*. Field Command, Defense Special Weapons Agency, Kirtland Air Force Base, New Mexico.
- Ristvet, Byron L., Lawrence J. Ashbaugh, Wayne R. Griffin
2007 *U12t Tunnel Interview*. Video disk on file, Desert Research Institute, Las Vegas, Nevada.
- Sargent, K.A. and P.P. Orkild
1973 *Geologic Map of the Wheelbarrow Peak-Rainier Mesa Area, Nye County, Nevada*. Miscellaneous Geologic Investigations Map I-754, Scale 1: 48,000, U.S. Geological Survey.
- Sawyer, D.A., Fleck, R.J., Lanphere, M.A., Warren, R.G., Broxton, D.E., and Hudson, M.R.
1994 Episodic caldera volcanism in the Miocene southwestern Nevada volcanic field – Revised stratigraphic framework, $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology, and implications for magnetism and extension: Geological Society of America Bulletin, v. 106, p. 1304-1318.
- Schoengold, C.R., M.E. Demarre, and E.M. Kirkwood
1996 *Radiological Effluents Released from U.S. Continental Tests 1961 through 1992*. Report DOE/NV-317 (Revision 1), U.S. Department of Energy, Nevada Operations Office, Las Vegas.
- Schoenholzer, W.J.
1970 *Test Group Engineer's Summary Report for ARPA Project Diamond Dust*. Reynolds Electrical & Engineering Co.
- Sites, Kenneth R. and David C Wetzel
1975 *Hussar Sword Series, Husky Ace Event: ROSES Experiment*. Report POR 6810, Director, Test Directorate, Field Command, Defense Nuclear Agency, Kirtland Air Force Base, New Mexico.

Slate, Janet L., Margaret E. Berry, Peter D. Rowley, Christopher J. Fridrich, Karen S. Morgan, Jeremiah B. Workman, Owen D. Young, Gary L. Dixon, Van S. Williams, Edwin H. McKee, David A. Ponce, Thomas G. Hildenbrand, W.C. Swadley, Scott C. Lundstrom, E. Bartlett Ekren, Richard G. Warren, James C. Cole, Robert J. Fleck, Marvin A. Lanphere, David A. Sawyer, Scott A. Minor, Daniel H. Grunwald, Randell J. Lacznaik, Christopher M. Menges, James C. Yount, and Angela S. Jayco

- 1999 Digital geologic map of the Nevada Test Site and vicinity, Nye, Lincoln, and Clark Counties, Nevada, and Inyo County, California. U.S. Department of the Interior, Washington, D.C.

Stapp, Darby C.

- 1997 Documenting a Cold War Nuclear Reactor: Attempting Innovation. *CRM* 20(13):38-40.

Swink, M.N., B.H. Collins, and T.D. Schwenk

- 1971 Project Diamond Mine Nitromethane Calibration Shot Project Officers Report. EG&G Inc., Albuquerque, New Mexico.

Taylor, E.M.

- 1986 *Impact of Time and Climate on Quaternary Soils in the Yucca Mountain Area of the Nevada Test Site*. M.S. thesis, University of Colorado, Boulder.

Titus, A.C.

- 1986 *Bombs in the Backyard: Atomic Testing and American Politics*. University of Nevada Press, Reno.

Tlachac, Eve M.

- 1991 Nuclear Testing. In *Nevada Comprehensive Preservation Plan*, edited by White, W.G., R.M. James, and R. Bernstein, pp. 25/1-25/12. Division of Historic Preservation and Archaeology, Department of Conservation and Natural Resources, Nevada Historical Society, Department of Museums and History, Carson City, Nevada.

Townsend, Margaret J.

- 2007 U12t Tunnel Interview. Audio disk on file, Desert Research Institute, Las Vegas, Nevada.

Trulio, John G. and Neil K. Perl

- 1974 *Calculations in Support of the Diamond Dust and Diamond Mine Events*. Applied Theory, Inc. Los Angeles, California.

U.S. Congress

- 1989 *The Containment of Underground Nuclear Explosions*. Report OTA-ISC-414, Office of Technology Assessment, Congress of the United States, U.S. Government Printing Office, Washington, D.C.

- Wesling, J.R., T.F. Bullard, F.H. Swan, R.C. Perman, M.M. Angell, and J.D. Gibson
1992 *Preliminary Mapping of Surficial Geology of Midway Valley, Yucca Mountain, Nye County, Nevada*. Report SAND91-0607, Sandia National Laboratories, Albuquerque, New Mexico.
- White, W., R. James, and R. Bernstein
1991 *Nevada Comprehensive Preservation Plan* edited by W White, R. James, and R. Bernstein. Nevada Division of Historic Preservation and Archaeology, Department of Conservation and Natural Resources, Nevada Historical Society, Department of Museums and History, Carson City.
- Whitener, Jack E.
1970 *Test Plan for Diamond Dust*. The Rand Corporation, Santa Monica, California.
- Whitney, J.W., R.R. Shroba, R.W. Simonds, and S.T. Harding
1986 *Recurrent Quaternary Movement on the Windy Wash Fault, Nye County, Nevada*. Volume. 18, Geological Society of America Abstracts with Programs.
- Wolff, Walter P.
1984 *A Typical Los Alamos National Laboratory Underground Nuclear Test*. Mini-Review LALP-84-47 Revision C.1, Los Alamos National Laboratory, Los Alamos, New Mexico.

DISTRIBUTION LIST

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
U.S. Department of Energy
P.O. Box 95818
Las Vegas, NV 89193-8518

Linda Cohn

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Technical Library
U.S. Department of Energy
P.O. Box 95818
Las Vegas, NV 89193-8518

U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office
Nuclear Testing Archive
P.O. Box 98521
Las Vegas, NV 89193-8521

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062

Department of Conservation and Natural Resources
Nevada State Historic Preservation Office
901 South Stewart St.,
Carson City, NV 89710

Archives and Records Center
Lawrence Livermore National Laboratory
P.O. Box 808, Mail Stop L-451
Livermore, CA 94551-0808

Reports Library
Lawrence Livermore National Laboratory
P.O. Box 808, Mail Stop L-659
Livermore, CA 94551-0808

DTRA/J4ET
1680 Texas St. SE
Kirtland AFB, New Mexico 87117-5669

Jeffrey Fraher

DTRIAC
1680 Texas St. SE Bldg. 20676
Kirtland AFB, NM 87117-5669