# Deployment of an Alternative Closure Cover and Monitoring System at the Mixed Waste Disposal Unit U-3ax/bl at the Nevada Test Site

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## ABSTRACT

In October 2000, final closure was initiated of U-3ax/bl, a mixed waste disposal unit at the Nevada Test Site (NTS). The application of approximately 30 cm of topsoil, composed of compacted native alluvium onto an operational cover, seeding of the topsoil, installation of soil water content sensors within the cover, and deployment of a drainage lysimeter facility immediately adjacent to the disposal unit initiated closure. This closure is unique in that it required the involvement of several U.S. Department of Energy (DOE) Environmental Management (EM) groups: Waste Management (WM), Environmental Restoration (ER), and Technology Development (TD). Initial site characterization of the disposal unit was conducted by WM. Regulatory approval for closure of the disposal unit was obtained by ER, closure of the disposal unit was conducted by ER, and deployment of the drainage lysimeter facility was conducted by WM and ER, with funding provided by the Accelerated Site Technology Deployment (ASTD) program, administered under TD. In addition, this closure is unique in that a monolayer closure cover, also known as an evapotranspiration (ET) cover, consisting of native alluvium, received regulatory approval instead of a traditional Resource Conservation and Recovery Act (RCRA) multi-layered cover. Recent studies indicate that in the arid southwestern United States, monolayer covers may be more effective at isolating waste than layered covers because of the tendency of clay layers to desiccate and crack, and subsequently develop preferential pathways. The lysimeter facility deployed immediately adjacent to the closure cover consists of eight drainage lysimeters with three surface treatments: two were left bare; two were revegetated with native species; two were allowed to revegetate with invader species; and two are reserved for future studies. The lysimeters are constructed such that any drainage through the bottoms of the lysimeters can be measured. Sensors installed in the closure cover provide soil water content data, whereas sensors installed in the lysimeters provide soil water content, soil water potential, soil temperature, and drainage data for a detailed evaluation of the cover performance. Revegetation establishes a stable plant community that maximizes water loss through transpiration and reduces water and wind erosion and ultimately restores the disposal unit to its surrounding Great Basin Desert environment.

## BACKGROUND

U-3ax/bl is a historic mixed waste disposal unit located within the Area 3 Radioactive Waste Management Site (RWMS) of the NTS (Figure 1). The unit formed

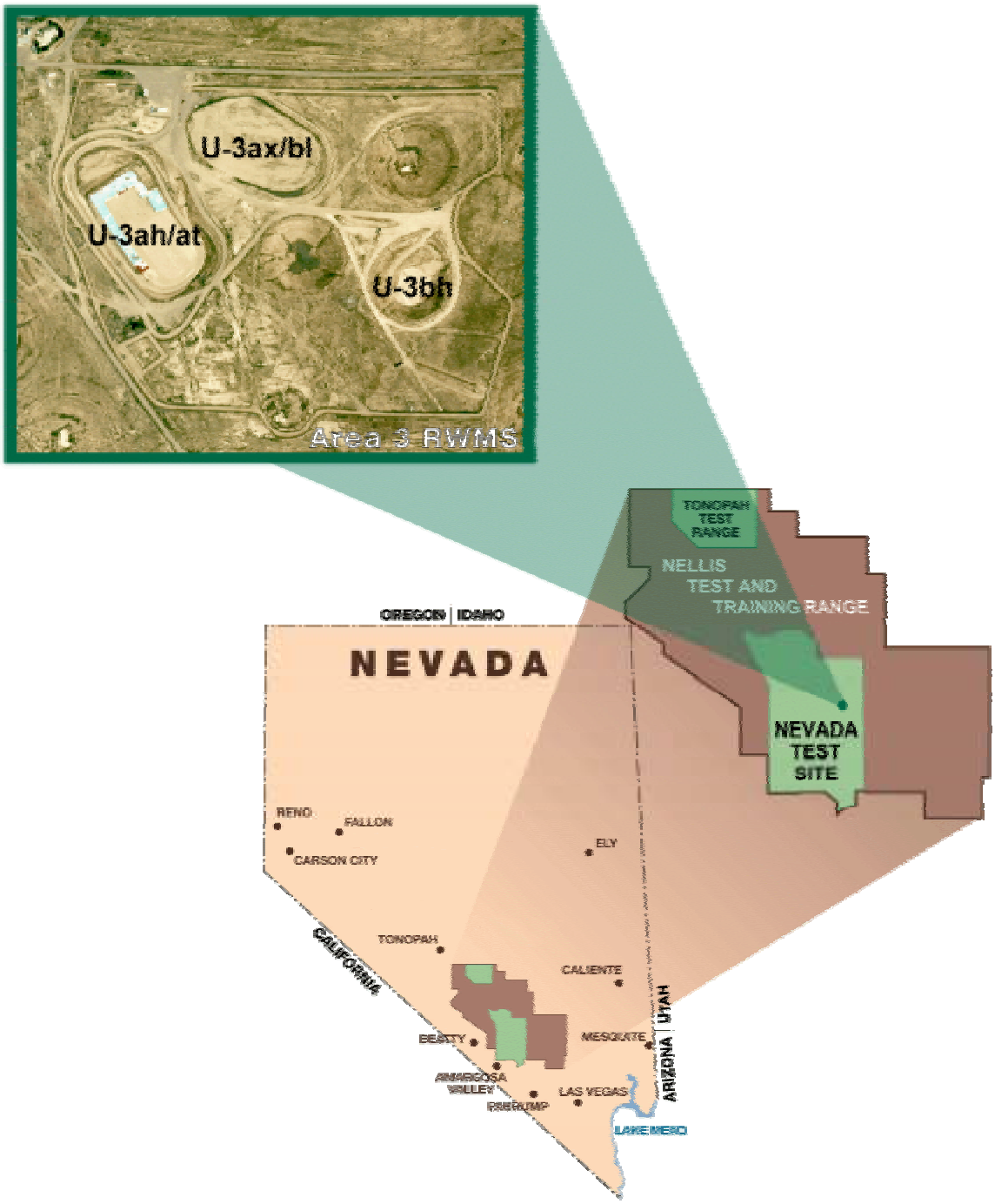


Figure 1. Location of U-3ax/bl within the Area 3 RWMS, the Nevada Test Site, and Nevada.

by excavating the area between two nuclear subsidence craters (U-3ax and U-3bl) was operationally closed in 1987, with a native alluvium soil cover ranging in thickness from approximately 2.4 to 3.0 m (8 to 10 ft). U-3ax/bl received 2.3 x $10^5$ $m^3$ (8.12 x $10^6$ $ft^3$) of waste from July 1968 to December 1987. Waste from NTS nuclear device testing generated approximately 95 percent of the total volume disposed in U-3ax/bl. The bulk of the waste (more than 99 percent by volume) is contaminated soil, scrap metal, debris from construction, containerized waste, and contaminated equipment. Tritium composes 90 percent of the radionuclide waste inventory. The disposal unit is classified as a mixed waste unit due to some hazardous constituents in the waste inventory such as lead and cadmium. Further details regarding the waste disposal unit can be found in the Performance Assessment (1), and in the final characterization (2) and closure (3) documents.

Closure of U-3ax/bl is unique in that it required the involvement of DOE EM groups WM, ER, and TD. Initial site characterization of the disposal unit was conducted by WM. Regulatory approval for closure of the disposal unit was obtained by ER, closure of the disposal unit was conducted by ER, and deployment of the drainage lysimeter facility was conducted by WM and ER with funding provided by the ASTD program within TD.

Site characterization of U-3ax/bl began in 1993, with subsequent reports on waste inventory and waste encapsulation approaches (4, 5) and continued with a series of angled boreholes drilled under and away from the disposal unit (6, 7). Original closure plans called for a traditional RCRA-type layered cover until this strategy was reevaluated due to concerns over differential subsidence and subsequent shearing of layers. In 1997, an internal study on closure covers and subsidence was conducted. The primary conclusion of this study was that the type of cover that would most likely accommodate subsidence was a monolayer-ET cover. A seven-year data record, from the weighing lysimeter facility in nearby Area 5 and modeling results provided supporting evidence that a partially vegetated, monolayer cover will effectively return infiltrating water to the atmosphere via evapotranspiration, even during wet years (8, 9). In addition, other studies indicate that in the arid southwestern United States, monolayer-ET covers may be more effective at isolating waste than layered covers because of the tendency of clay layers to desiccate and crack and subsequently develop preferential pathways (10, 11). A monolayer-ET cover also recently received regulatory approval at a DOE site at the Central Nevada Test Area. That closure cover was constructed and revegetated in September and October 2000 (12). Ultimately, revegetation of the monolayer closure cover establishes a stable plant community that maximizes water loss through transpiration and reduces water and wind erosion and restores the disposal unit to its surrounding environment.

U-3ax/bl is a mixed waste disposal unit, with both radioactive and hazardous constituents. The U.S. Environmental Protection Agency (EPA) has regulatory authority over the hazardous waste component, whereas DOE has regulatory authority over the radioactive waste component. In Nevada, the Nevada Division of Environmental Protection (NDEP) has EPA regulatory authority. In 1999, the responsibility of U-3ax/bl final closure was transferred from WM to ER due to ER's experience in closing ER sites with regulatory approval from the NDEP. Since that transferal, ER has succeeded in

getting a monolayer-ET cover and a groundwater monitoring waiver approved by the NDEP for U-3ax/bl.

In 1998, funding was secured from ASTD to deploy a drainage lysimeter facility, constructed such that soil conditions are identical to the closure cover of U-3ax/bl, that would measure any drainage through the lysimeters and thus provide an indirect measure of drainage through the closure cover. Justifications for funding the ASTD project were many: drainage lysimeters were considered the best strategy for measuring drainage through the waste cover; significant cost savings were realized in that investment in a monitoring facility would be considerably less than constructing a layered cover, since data provided by the facility are expected to demonstrate excellent cover performance; the facility will address issues such as the uncertainty of surface treatment of monolayer-ET covers such as mulching type, vegetation type, and vegetation density; and these results are applicable throughout the DOE complex, particularly to other arid and semi-arid sites.

## SITE DESCRIPTION

Area 3 is located in Yucca Flat, within the northeast quadrant of the NTS. The Yucca Flat watershed is a structurally closed basin encompassing an area of approximately 780 $km^2$ (300 $mi^2$). The structural geomorphology of Yucca Flat is typical of the Basin and Range Physiographic Province.

Yucca Flat lies in one of the most arid regions of the country. The climate of the area is characterized by a large number of cloudless days, low precipitation, and high daily temperatures, especially in the summer. Average annual precipitation is approximately 165 mm (6.5 in). The majority of rain falls during two peak seasons, with a greater peak in the winter and a lesser one occurring during the summer months. Winter storms tend to be transitory low-pressure systems from the west, whereas the summer storms tend to be convective storms from the south or southeast. Annual potential evapotranspiration calculated using one form of the Penman equation (13) is approximately 1.63 m (64 in). The location of the drainage lysimeter facility relative to U-3ax/bl is shown in Figure 2.

## U-3AX/BL CLOSURE COVER

Soil water content sensors were installed in the closure cover of U-3ax/bl in October 2000. Time-domain reflectometry (TDR) probes were installed at depths ranging from 0.3 to 2.4 m (1 to 8 ft), with one probe every 0.3 m (1 ft). TDR probes were installed at a distance of approximately 46 m (150 ft) from the edge of the cover. A profile of eight probes (a stack) was installed at four locations within the cover, for a total of 32 probes. Automated water content measurements are taken daily. Figure 3 shows a cross-section schematic of the sensor installation.

In November 2000, construction of the final closure cover of U-3ax/bl began with the application of 30 cm (1 ft) of soil from a nearby borrow pit to the original 2.4 to 3.0 m (8 to 10 ft) thick operational closure cover. The final closure cover ranges in thickness from approximately 2.7 to 3.4 m (9 to 11 ft).

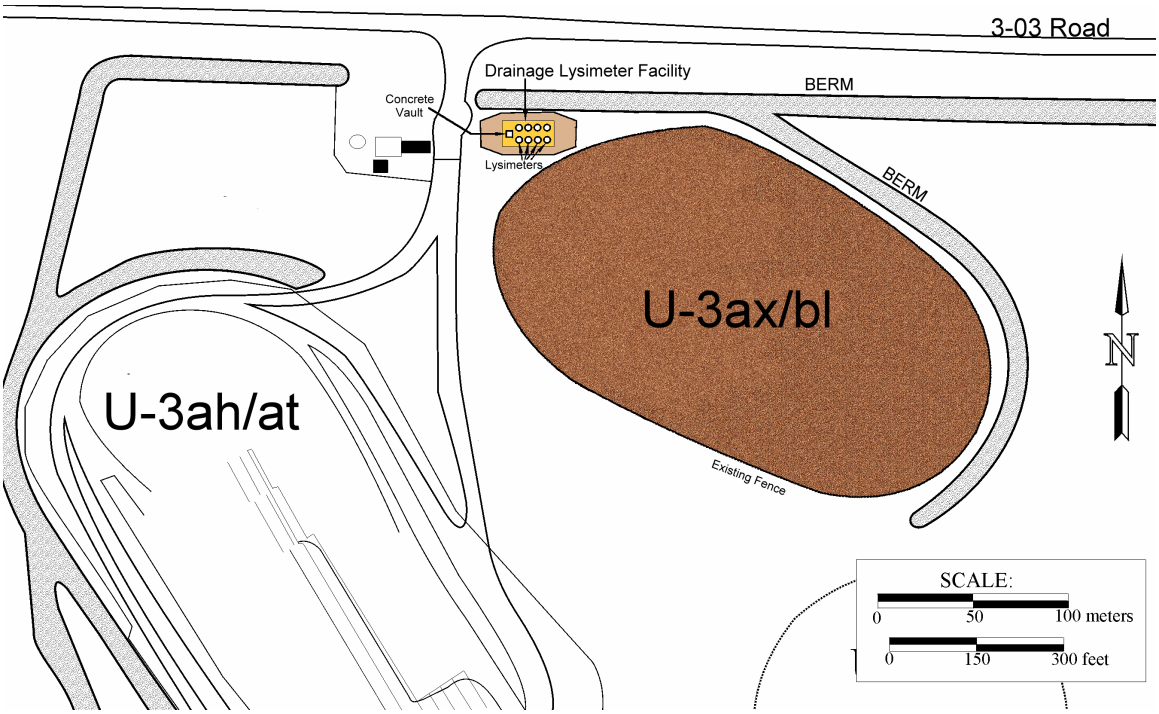


Figure 2. Location of U-3ax/bl and the ASTD drainage lysimeter facility.

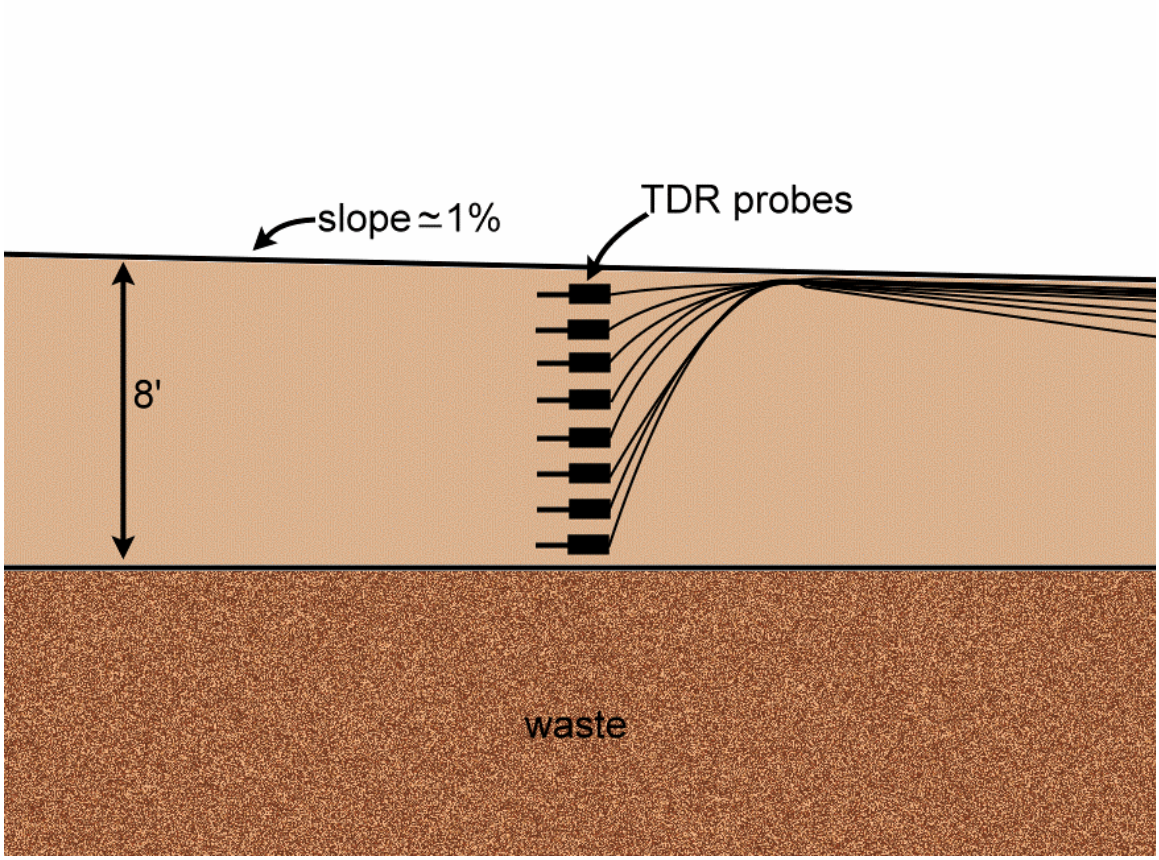


Figure 3. Schematic cross-section of sensor locations in the U-3ax/bl closure cover.

Revegetation activities began in December 2000, with seeding of native species and straw mulching of the closure cover. Conservative modeling results indicate that revegetation of the closure cover may take ten years to reach maturity, during which time soil moisture within the closure cover may increase (3). However, revegetation efforts in Area 5 (with slightly less rainfall than Area 3) resulted in a stable vegetation community and reduced soil moisture levels within one season (8).

## ASTD DRAINAGE LYSIMETER FACILITY

The lysimeter facility deployed immediately adjacent to the closure cover (Figure 2) consists of eight drainage lysimeters with three surface treatments: two were left bare, two were revegetated with native species, two were allowed to revegetate with invader species, and two were reserved for future studies. The lysimeters are constructed such that any drainage through the bottoms of the lysimeters can be measured. Sensors installed in the lysimeters provide soil water content, soil water potential, soil temperature, and drainage data for a detailed evaluation of closure cover performance, as well as provide input data for model simulations. A nearby meteorology station provides atmospheric boundary conditions including precipitation.

Placement of soil water content sensors (TDR probes) and soil water potential sensors (heat dissipation probes) are shown in Figure 4. Water potential data from the heat dissipation probe measurements will be used to calculate drainage through the lysimeters and will be compared to the direct measurements of drainage. This comparison will yield important information on the accuracy of heat dissipation probes for calculating deep drainage, since installation of drainage lysimeters is not generally feasible.

## CONCLUSIONS

Final closure of U-3ax/bl is complete: approximately 30 cm of topsoil was applied to the operational cover; the topsoil was seeded and mulched; the waste cover was instrumented with soil water content sensors; and the drainage lysimeters were instrumented with soil water content and water potential sensors and deployed immediately adjacent to the disposal unit to directly measure the total water balance, including drainage through the lysimeters.

Data collected from the U-3ax/bl cover monitoring system, and the drainage lysimeter facility are expected to demonstrate the successful performance of a monolayer-ET cover, and may facilitate deployment of future monolayer-ET closure covers at other arid and semi-arid DOE sites.

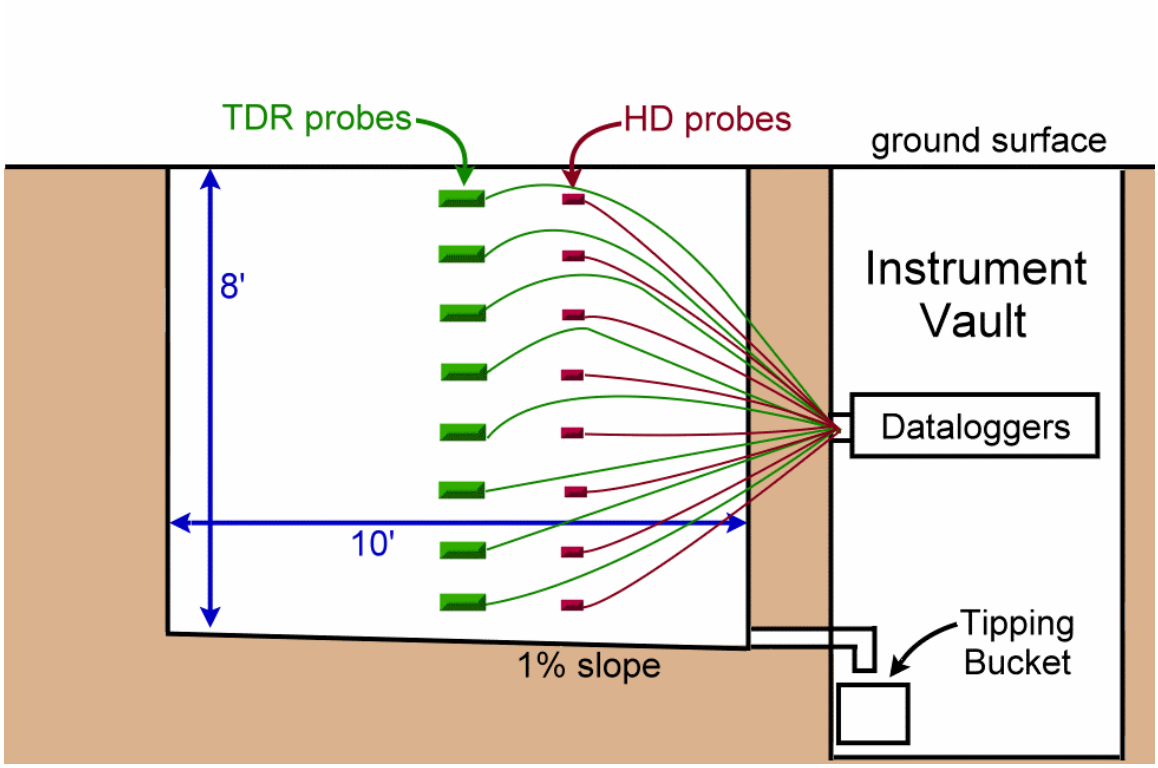


Figure 4. Schematic cross-section of sensor locations in each of the eight drainage lysimeters.

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