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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

Final closure of the Mixed Waste Disposal Unit U-3ax/bl at the Nevada Test Site (NTS) was achieved by the successful deployment of Resource Conservation and Recovery Act (RCRA) alternative cover design. This closure is unique in that a mono-layer closure cover, also known as an evapotranspiration (ET) cover, consisting of native alluvium, received regulatory approval instead of using a traditional RCRA multilayered cover. Recent studies indicate that in the arid southwestern United States, mono-layer covers may be more effective at isolating waste than layered covers because of the tendency of layered systems to fail over time.

Approval of the design was contingent on the installation of soil water content sensors within the cover to monitor performance during the post-closure monitoring period. Additional funds from Technology Deployment (TD), through the Accelerated Site Technology Deployment (ASTD) program, enabled a lysimeter facility to be installed immediately adjacent to the disposal unit. This facility will provide data for a detailed evaluation of closure cover performance and running numerical models.

Final closure of U-3ax/bl and deployment of the ASTD drainage lysimeter facility is a U.S. Department of Energy (DOE) Environmental Management (EM) success story, requiring involvement from Waste Management, Environmental Restoration, and TD groups, and paving the way for future mono-layer ET closure covers at other arid and semiarid DOE sites.

BACKGROUND

U-3ax/bl is a historic mixed waste disposal unit (closed in 1987) located on the NTS. The unit is made up of two subsidence craters formed by underground testing. Initially debris was disposed of in the U-3ax crater. As U-3ax filled, material between U-3ax and the adjacent crater (U-3bl) was used to cover the debris. Eventually the two craters became one. The majority of the waste disposed in U-3ax/bl is debris generated from nuclear device testing at the NTS. The physical form of the waste consists of (more than 99 percent by volume) contaminated soil, scrap metal, construction debris, containerized waste, and contaminated equipment. Tritium composes 90 percent of the radionuclide activity. The disposal unit was classified as a mixed waste unit due to some hazardous constituents in the waste inventory such as lead and cadmium.

The U-3ax/bl disposal unit was the first of many closures which will take place at the NTS. The U.S. Department of Energy Nevada Operations Office (DOE/NV) has projected that approximately 90 acres of landfills will require closure by 2011. Because of the number of pending future closures DOE/NV initiated the Integrated Closure Program (ICP) in 1993. The ICP was built on a simple premise: similar wastes in similar environments will receive similar closures. Adopting this premise meant that sites need adequate characterization. Following characterization, scientific and engineering principles were used to develop closure alternatives.

Site characterization of U-3ax/bl began in 1993. Historical waste disposal and photographic records were gathered and combined with the existing electronic database to build detailed information on waste forms, volumes, and activities. A hydrogeologic assessment of the unsaturated zone was initiated by drilling three angled boreholes, two beneath U-3ax/bl and one in undisturbed alluvium adjacent to the disposal unit. Waste form information was used to analyze subsidence potential. Meteorological records were compiled and a micro-meteorological station was built at the site. Coupled with geomorphological studies, the meteorological records were used to conduct a flood assessment for the area. From the hydrogeologic and meteorological data several numerical modeling studies were conducted. The studies focused both on cover performance and the performance of the entire unsaturated zone. A plant and animal study compiled the available information on the indigenous species and the effect they may have on a cover.

This information provided a foundation from which to analyze the various cover types. The DOE/NV convened a group of cover design and construction experts to develop design objectives with which to evaluate various cover design options. Design objectives included: erosion control, limit infiltration, enhance evapotranspiration, deter animal intrusion, accommodate subsidence, and perform over the long-term with minimal maintenance. A survey of other DOE and other private sites in arid to semiarid regions was used to generate initial cover designs for evaluation. The first designs evaluated were of RCRA-type covers (layered systems). It was noted during this evaluation that the typical RCRA cover was not designed with the arid west in mind. However, many of the designs were able to meet the established functional criteria excluding subsidence and long-term minimal maintenance. The only cover system, which adequately addressed all of the performance objectives, was the mono-layer ET cover.

In 1994, a water balance study was initiated at the NTS. The focus of the study was to characterize the movement of water within the near-surface alluvium. Two weighing lysimeters (one vegetated, the other without plants) measure the change in water storage, yielding precise and direct measurements of evaporation and ET. It was recognized that these lysimeters were good analogues for the mono-layer cover. Data from the lysimeter research station have been used to calibrate predictive models for long-term performance of the mono-layer ET cover design. Both the modeling results and data collected to date show that the mono-layer ET cover design is extremely effective.

U-3AX/BL CLOSURE SYSTEM DESIGN

The U-3ax/bl cover consists of approximately 10 feet of compacted native alluvium and an additional foot of topsoil, which was added to the cover to establish a suitable environment for revegetation. The U-3ax/bl cover has an areal extent of approximately 7.5 acres. The closure plan for the U-3ax/bl was approved by the Nevada Division of Environmental Protection (NDEP) with one contingency. The NDEP required that some type of cover monitoring system be deployed to show adequate performance. 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 1 to 8 feet, with a probe spaced every foot. TDR probes were installed at a distance of approximately 150 feet from the edge of the cover. A profile of eight probes (a stack) were installed at four locations within the cover, for a total of 32 probes. Automated water content measurements will be taken daily.

Revegetation activities were finished in December of 2000 with the seeding of native species and straw mulching of the closure cover. Ultimately, revegetation of the mono-layer cover will establish a stable plant community that maximizes water loss through transpiration and reduces water and wind erosion. An additional benefit is that this design restores the disposal unit to its surrounding environment. Conservative modeling results indicate that the plant community may take ten years to reach maturity, during which time soil moisture within the cover may increase. However, revegetation efforts at other areas of the NTS resulted in a stable plant community and reduced soil moisture levels within one season.

Additional funds from TD, through the ASTD program, enabled a lysimeter facility to be installed immediately adjacent to the disposal unit. The lysimeter facility consists of eight drainage lysimeters with three surface treatments: two will be kept bare, two will be allowed to vegetate naturally with invader species, two were revegetated consistent with the U-3ax/bl closure cover, and two are reserved for future studies. The lysimeters were constructed such that any drainage throughout the bottoms 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.
In addition to monitoring moisture within the cover, six subsidence markers will be surveyed on a biannual basis. During the post-closure care period, the cover will be repaired so that the “as built” design is preserved.

CONCLUSION

The U-3ax/bl closure was a multistage process consisting of characterization, development of design criteria, engineering design and analysis, regulatory approval, final construction, and post-closure monitoring. The U-3ax/bl is a product of the ICP and will be used as a template for future NTS closures. This process has and will result in a savings of both time and money for NTS closures. Final closure of U-3ax/bl and deployment of the ASTD drainage lysimeter facility is a EM success story, requiring involvement from Waste Management, Environmental Restoration, and TD groups, and paving the way for future mono-layer ET closure covers at other arid and semiarid DOE sites.