JUSTIFICATION FOR AN ALTERNATIVE LANDFILL DESIGN FOR THE MIXED WASTE DISPOSAL UNIT AT THE AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE, NEVADA TEST SITE

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ABSTRACT

The Pit 3 Mixed Waste Disposal Unit is located in Frenchman Flat within the Area 5 Radioactive Waste Management Site on the Nevada Test Site. The unit disposes on-site generated mixed waste from environmental cleanup activities. The Nevada Site Office is applying for a permit to bury off-site mixed waste and one component of the application is a cost-effective alternative landfill design. This design uses a defense-in-depth systems approach consisting of combined acceptance, operation and disposal practices, a vegetated, monolithic evapotranspiration closure cover, and lateral and lower buffer zones of native alluvial soil that enhance the natural protection provided by the arid climate setting and deep groundwater. The waste zone is located in a region of predominantly upward flow of liquid and vapor water more than 200 meters above the water table. These hydrologic features combined with the thick vegetated closure cover provide reasonable expectation of no drainage through the cover or the underlying waste zone. Verification of this conclusion is provided by decade long bare and vegetated lysimeter experiments, monitoring of operational covers, and numerical modeling of water and contaminant migration in the near surface disposal environment. Protection of the surface waters and groundwater during the operational phase will be provided by containzeration/encapsulation of waste, surface drainage features with a water collection trench, incremental coverage of waste by an operation cover and the highly evaporative conditions of the disposal setting. Limitations in requirements for application of evapotranspiration closure covers are not applicable to the Nevada Test Site setting and the Pit 3 disposal unit is a premier site for deployment of an alternative landfill design.

INTRODUCTION

The Pit 3 Mixed Waste Disposal Unit (MWDU) was constructed in 1985 within the Area 5 Radioactive Waste Management Site (RWMS) at the U. S. Department of Energy (DOE) Nevada

Test Site (NTS). The RWMS is located in the Frenchman Flat basin on the NTS approximately 105 km northwest of Las Vegas, Nevada (Figure 1). The facility is used to dispose defense-

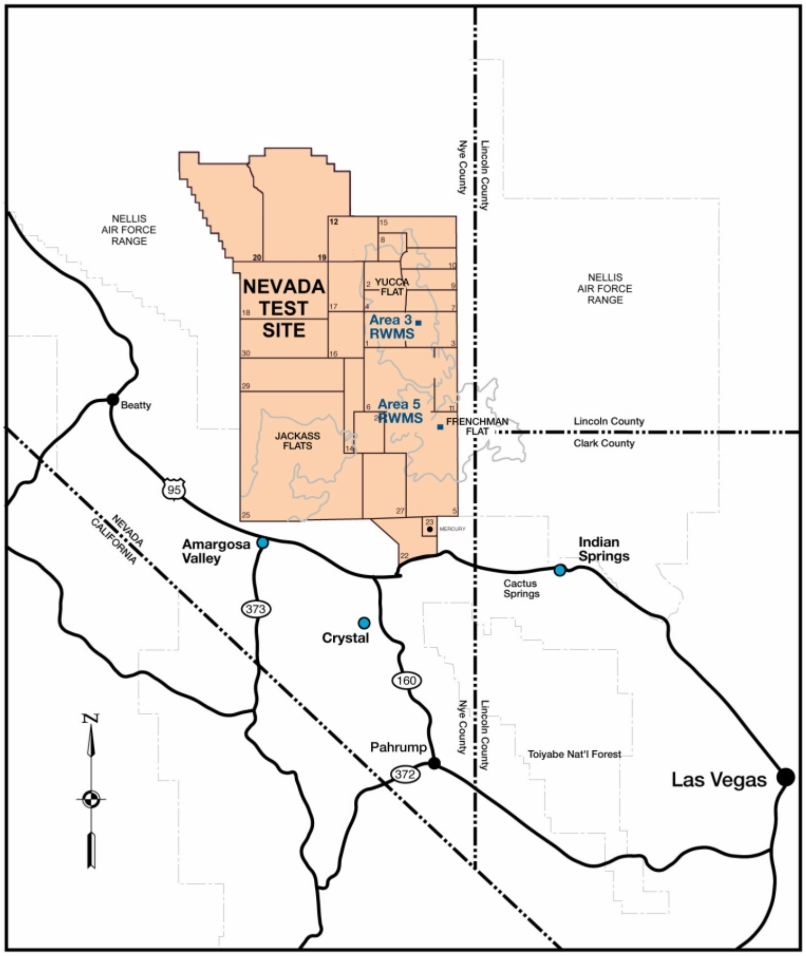


Fig. 1. Location of the Nevada Test Site in southern Nevada. The Area 5 Radioactive Waste Management Site containing the Pit 3 Mixed Waste Disposal Unit is in Frenchman Flat in the southeast part of the Nevada Test Site.

generated, low-level radioactive waste from cleanup activities at the NTS and across the DOE complex. The irregularly shaped Pit 3 MWDU is approximately 320 m long with a varying width, and an average depth of 9.1 m (Figure 2). The Pit 3 MWDU design capacity is about 50,000 m^3 with a remaining disposal capacity of 20,000 m^3. The Pit 3 MWDU has operated continuously under Resource Conservation and Recovery Act (RCRA) interim status and currently only low-level radioactive mixed waste (LLMW) generated during environmental cleanup activities on the NTS is accepted for disposal.

The National Nuclear Security Administration Nevada Site Office (NNSA/NSO) is applying for a RCRA Part B permit from the State of Nevada for disposal of off-site generated LLMW to assist in the environmental management cleanup activities for the DOE complex. One component of the permit application is the technical justification for an alternative landfill design.

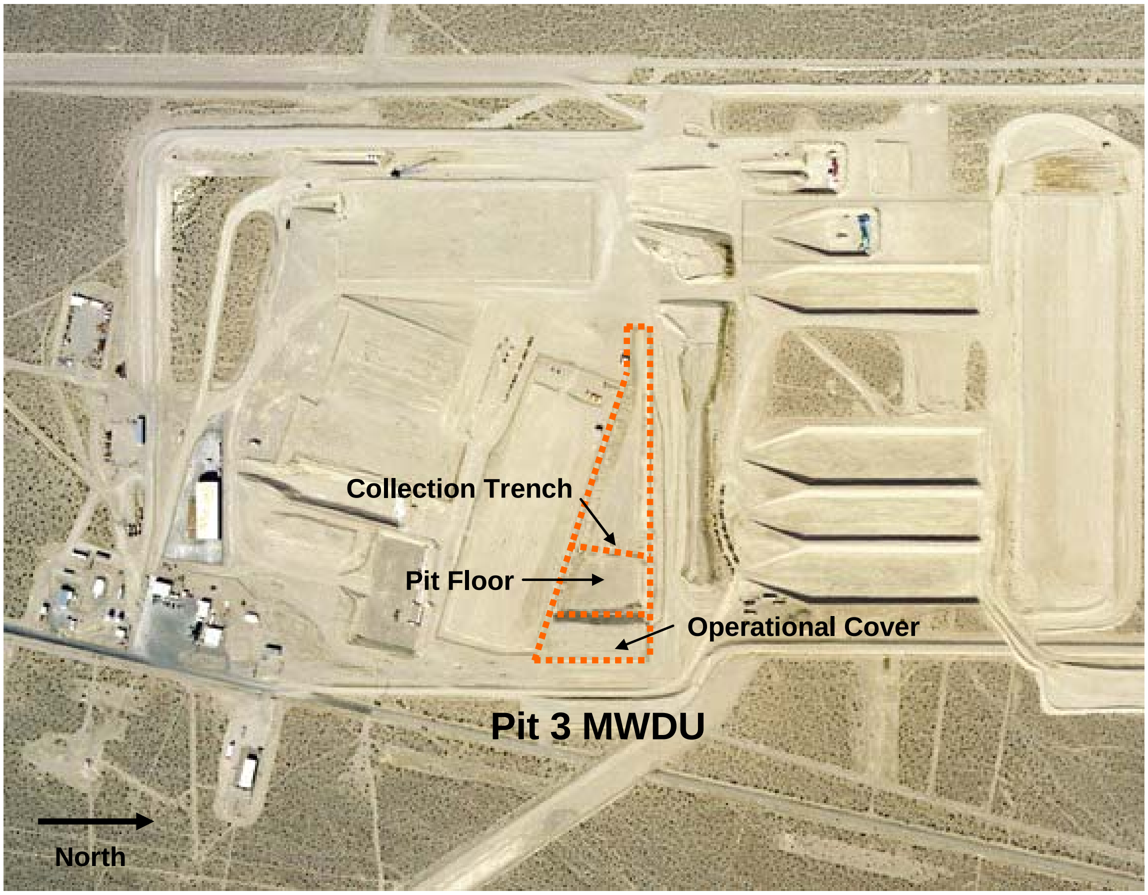


Fig. 2. Aerial photograph of the Area 5 RWMS showing the outlines of the Pit 3 MWDU. The area labeled operational cover is the older eastern disposal area of Pit 3 now covered by an operational cover. The area labeled pit floor is the unused area for future disposal of MLLW. It is bounded on the west by the collection trench, the designed low area of the pit that will collect any surface drainage from storm events. The area west of the collection trench provides access to the pit and will not be used for disposal of MLLW.

The alternative landfill design uses locally available alluvial soils for construction of a thick (4.0 m) vegetated, monolithic evapotranspiration (ET) closure cover above the waste zone. The design is consistent with adjacent disposal units in the Area 5 RWMS and uses a defense in depth concept to protect surface waters and groundwater including: a) waste acceptance, operational practices and design components of the disposal unit that minimize the potential for leachate generation, b) a thick vegetated closure cover with a high storage capacity, c) location of the waste zone in a region of predominantly slow *upward* movement of liquid and vapor water d) lateral and lower buffer zones of native alluvium to contain potential migration of contaminants from episodic infiltration events, and e) deep groundwater with no aerially distributed recharge under current climatic conditions. The high storage capacity of the alternative closure cover holds infiltrated moisture above the waste zone until it is removed by combined evaporation and plant transpiration (evapotranspiration or ET), natural processes that are particularly efficient in the arid desert climate. The proposed design is less expensive to construct and maintain than a conventional RCRA closure cover and is more resistant to the effects of subsidence.

The requirements for an alternative landfill designed are described in 40 CFR 264.301(b) and the regulatory basis for meeting those requirements is presented in the MLLW permit application to the State of Nevada. This paper provides the technical basis for the alternative landfill design and the adaptation of natural and engineered design components to the hydrogeologic setting of the Area 5 RWMS. We conclude with a summary of how the design accommodates limitations in the applicability of alternative ET closure covers (1-7).

BACKGROUND

Standard or conventional RCRA landfill closure covers generally include single or multiple soil barrier layers or liners (clay/silt, geosynthetic clays or geomembrane liners) above the zone of waste burial (1-7) and may include liner systems below the waste zone to further restrict contaminant migration and/or collect leachate. The goal of multi-layer cover designs is to reduce or eliminate percolation through the bottom of a closure cover and therefore protect the waste zone from conditions that could result in contaminant migration to groundwater. Conventional RCRA cover designs are often described as "resistive" covers because drainage is controlled through addition of one or multiple layers that function as low-permeability barriers (1,6). They may include water storage layers that remove water through ET as design components of the overall cover system. Multi-barrier cover designs perform well in areas of high precipitation where the primary pathway for contaminant transport is downward to shallow groundwater. However, the RCRA cover specifications are largely independent of long-term site specific features such as climate, vegetation and soil characteristics that contribute to the protection of surface water and groundwater (8). The RCRA closure covers are not as efficient at protecting surface and subsurface waters in arid or semi-arid climates where the dynamics of precipitation, infiltration and ET can induce both downward and upward flow of water and water vapor. Additionally barrier layers of RCRA covers can degrade with successive cycles of wetting and drying, soil disruption associated with plant-root development and subsidence of the waste zone. Increasingly, the geotechnical community advocates the use of ET covers for disposal sites located in arid and semi-arid climatic settings where potential ET often equals or exceeds annual precipitation. These closure covers are more properly called water balance or ET covers because they rely on the storage capacity of cover soils and ET to remove water before it can drain through the cover. The ET cover designs usually have three design components including (6,7):

1. Thick zone(s) of fine-grained soils with high water storage capacity,
2. Reliance on natural processes of evaporation and plant transpiration for removal of infiltrated water in arid or semi-arid climatic settings, and
3. Locally available soils for ease of construction and reduced cost.

With proper design and an appropriate climate setting the performance of a water balance or ET cover can equal or exceed the performance of conventional RCRA cover designs where performance is measured as drainage through the bottom of a cover. While alternative landfill designs are well accepted in the technical community, they are regarded as new "alternative" technology by regulators. There are currently no written requirements for conducting a regulatory review of an alternative landfill design (1).

Hydrogeologic Setting of the Area 5 RWMS

The Area 5 RWMS is sited in alluvial deposits of the Frenchman Flat basin that consist of unconsolidated to weakly consolidated fragmental debris of volcanic and carbonate rocks eroded from the surrounding mountains. The climate is characterized by low precipitation, large diurnal temperature ranges, and moderate to strong winds that all maintain high potential evaporation. The average annual precipitation in Frenchman Flat is 12.7 cm. The potential evaporation calculated using the Penman equation and data collected from a local meteorology station is 157 cm. The average ratio between potential evaporation and precipitation at the Area 5 RWMS is 12.4 (9), indicative of extremely evaporative conditions.

The hydrological properties of alluvium below the Area 5 RWMS have been established from extensive site characterization studies summarized in Shott *et al*. (10). The upper 1 to 2 m of undisturbed alluvium forms a hydrologically active region where changes in the magnitude and direction of liquid and vapor fluxes vary temporally dependent on the magnitude and frequency of episodic infiltration, evapotranspiration, and biotic activity (Figure 3). Below the dynamic zone, dry evaporative surface conditions, low water contents, efficient transpiration of moisture by desert vegetation and hydraulic properties of the soils result in upward flow of water from as deep as 35 m (11).

Below the upward flow region, water-potential measurements show the existence of a static region extending between 35 to 90 m below the surface (10,12). Here, essentially no liquid flow is occurring.

Below the static region, higher water contents allow steady downward flow to the water table (236 m below the surface). The downward flux is low and the water in the lower part of the unsaturated zone is inferred to be old and derived from past periods of wetter climate (12). Under current conditions, there is effectively no surface recharge to the water table beneath the Area 5 RWMS. The combination of deep groundwater, low water content of soils and low rates of predominant upward flow of liquid and vapor water provide an ideal natural setting for isolation of radioactive waste.

The dominant processes of fate and transport of contaminants affecting disposed waste in the Area 5 facility have been studied through characterization activities and numerical modeling studies for performance assessment studies (10). Under current climate conditions, transport of contaminants in the shallow unsaturated zone is mostly upward and is controlled by the combined processes of plant root uptake, burrow excavation by small mammals and insects, upward advection of water, and diffusion in air and water. The dynamics of these processes vary on diurnal, seasonal and climate cycles (for example, El Nino cycles).

Closure

The closure plans for disposal units in the Area 5 RWMS include construction of a thick vegetated monolithic ET closure cover to minimize radiological releases along multiple exposure pathways (atmospheric, all pathway, inadvertent human intruder, radon flux) (13). A thick (4.0 m) vegetated closure cover will be used for the following reasons:

1. To minimize estimated releases for an exposure scenario that includes excavation of a basement in a resident located on a waste unit,
2. To reduce the surface radon flux for radon-producing waste streams (high contents of ^{230}Th and ^{226}Ra),
3. To minimize surface releases from biotic activity, and
4. To minimize the effects of subsidence and surface erosion.

Given the facility requirements for a 4-m closure cover, it is logical and cost effective to propose a similar closure design for the Pit 3 MWDU since this design meets the equivalency requirements of the RCRA regulations. The Pit 3 MWDU closure cover will be sloped in conformity with the adjoining waste cells to avoid post-closure drainage onto the disposal units.

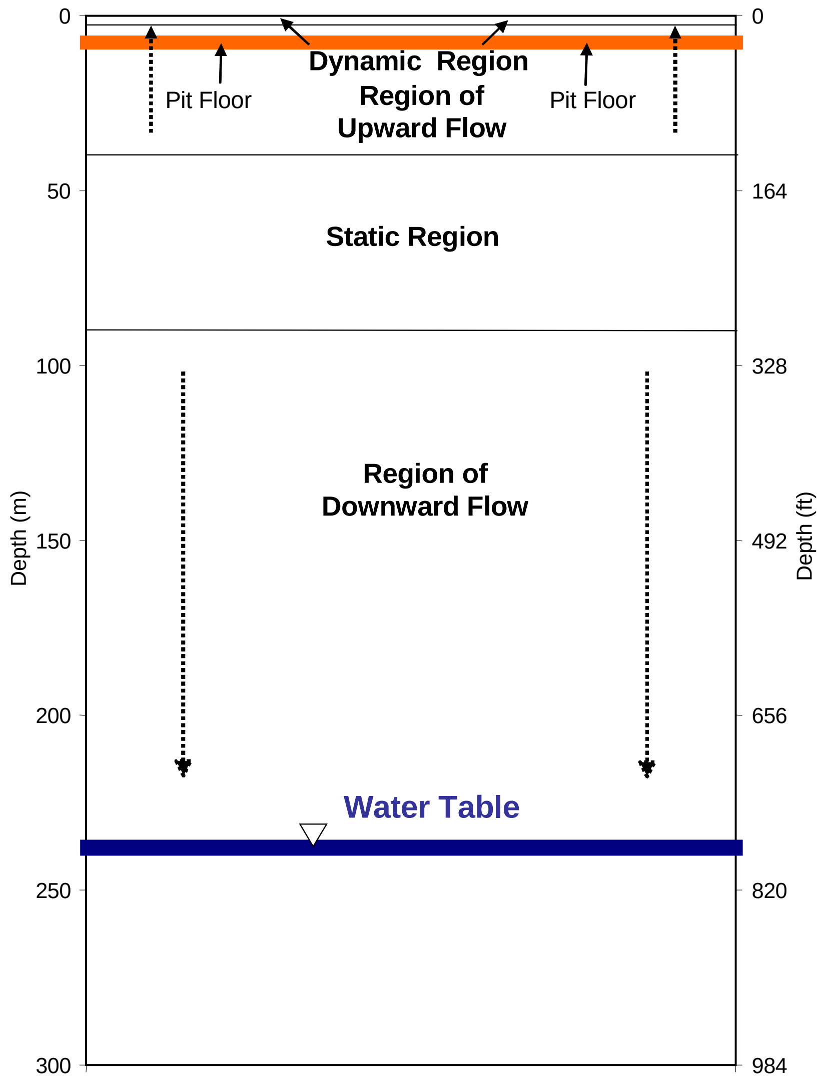
ALTERNATIVE LANDFILL DESIGN

Recognizing the very positive hydrogeologic setting for shallow land disposal of hazardous and radioactive waste at the Area 5 RWMS, the NNSA/NSO is proposing an alternative landfill design for the MWDU that utilizes and compliments the natural setting. The main components of the design are illustrated on Figure 4 and consist of a 4-m thick, vegetated monolithic ET closure cover and associated buffer zones of native alluvium flanking and beneath the waste disposal zone. The design components for both the operational phase (active disposal of waste) and the closure phase are described in the following sections.

Alternative landfill design: Operational Phase

The Pit 3 MWDU is an unlined disposal cell where waste is placed in tiers on bare alluvial soil that forms the pit floor. Waste disposed in the Pit 3 MWDU includes both LLW and LLMW. Disposal of LLW began in Pit 3 in 1985 and was discontinued in 1990. The LLMW waste disposed between 1987 and 1990 consists exclusively of solidified sludge (pondcrete) that originated from Pond 207A at the Rocky Flats Plant in Colorado. Mixed waste streams disposed since 1996 are primarily soil and other dry solids with hazardous metals or volatiles, or both, resulting from cleanup during environmental remediation at the NTS.

Waste streams accepted for disposal at the Pit 3 MWDU must meet Land Disposal Restriction (LDR) Treatment Standard including underlying hazardous constituents and specific EPA waste codes. Wastes disposed in the Pit 3 MWDU are containerized dry solids (free liquids are prohibited), wastes stabilized by the addition of cement, or in an encapsulated form. The disposed waste will not change the favorable hydrologic properties of the disposal setting and the waste packaging significantly reduces the potential for leaching and migration of contaminants.



Dynamic Region: magnitude and the direction of liquid fluxes are variable and determined by episodic infiltration, evapotranspiration, and processes of biotic transport.

Region of Slow Upward Flow: region where the combination of low precipitation and high potential evapotranspiration leads to a dry zone inducing upward flow of pore water in the unsaturated zone from as deep as about 35 m. Average upward velocity: 0.02 mm/yr

Waste zone located in region of upward flow

Static Region: region of no vertical liquid (balance of matric suction and gravitational forces). The thickness and the depth below the surface of this region changes with the physical/textural properties of alluvium and in situ water content.

Region of Slow Downward Flow: region of steady downward flow (increased water contents allow downward drainage). Water in the vadose zone currently recharging the water table probably infiltrated during past pluvial climate cycles.

No aerially distributed recharge to the groundwater table under current conditions.

Fig. 3. Schematic diagram of flow regions in the vadose zone beneath the Area 5 RWMS. Orange-shaded layer is the waste zone and the blue-shaded layer is the water table.

Pit Design: During the operational phase, the exposed floor of the Pit 3 MWDU, which consists of compacted alluvial soils, will be sloped away from the active waste front, toward a trapezoidal-shaped collection trench that trends north-south across the pit and defines the approximate western boundary of the disposal unit (Fig. 2). Waste containers not buried beneath the operational cover have a short exposure period when precipitation events potentially could generate leachate. Any downward drainage through the containerized waste will infiltrate into the alluvial soils beneath the trench floor. With larger or closely spaced precipitation events, some leachate may be transported as sheet flow across the sloped floor of the pit and accumulate in the collection trench.

Lateral Buffer Zone. The alternative landfill design includes a 3-m lateral buffer zone of native alluvial soil around the sides of the Pit 3 MWDU. This zone will contain any lateral transport of moisture and contaminants and maintain a buffer that prevents interference with or from adjacent disposal units. To quantify the effectiveness of this lateral buffer zone, two-dimensional modeling was conducted using the HYDRUS-2D vadose zone simulation model to estimate the extent of the lateral spread of a wetting front at the Pit 3 MWDU. A model domain was set up corresponding to a vertical cross-section along the long axis of Pit 3. Moisture was introduced into the modeling domain equal to 5.25 times the amount of water in a 100-year, 24-hour storm precipitation event without any runoff. The estimated maximum spread of the wetting front was 2.5 m at a depth of 1 m. The thickness of the proposed lateral buffer for the Pit 3 MWDU is 3 m, a thickness that exceeds the modeled lateral spread of moisture (2.5 m) associated with a maximum precipitation event with boundary conditions optimized for infiltration.

Lower Buffer Zone. The next component of the alternative landfill design is a lower buffer zone below the waste zone consisting of 20 m of largely undisturbed native alluvium. The purpose of the lower buffer zone is to contain and slowly disperse future wetting fronts that could move downward through the waste zone into the buffer zone and contain any contaminants that migrate with the wetting front. The 20 m lower buffer is in the zone of small magnitude upward flow of liquid and vapor (10). Any wetting front that transports contaminants will gradually equilibrate with the background moisture content of the underlying alluvial soils and slowly return to ambient conditions of upward flow.

The thickness of the lower buffer zone could extend to the groundwater table (236 m below the surface). A 20-meter thickness for the lower barrier is the thickness of alluvial soils required, from modeling studies, to attenuate the downward migration of a major percolation pulse (14). A scenario was simulated of infiltration, redistribution, bare-soil evaporation, and precipitation for an Area 5 disposal unit using representative hydraulic properties and initial conditions from the Area 5 performance assessment (10, 14). A pulse of water was introduced into the waste zone of a representative disposal unit assuming that 25 or 50 percent of the waste inventory contained excess moisture where excess moisture is a water content that exceeds the field capacity of the alluvial soil. The VS2DT computer program was used to simulate downward migration of wetting fronts associated with drainage from wet waste assuming isothermal, two-dimensional movement of liquid water in variably saturated porous media. The simulated wetting

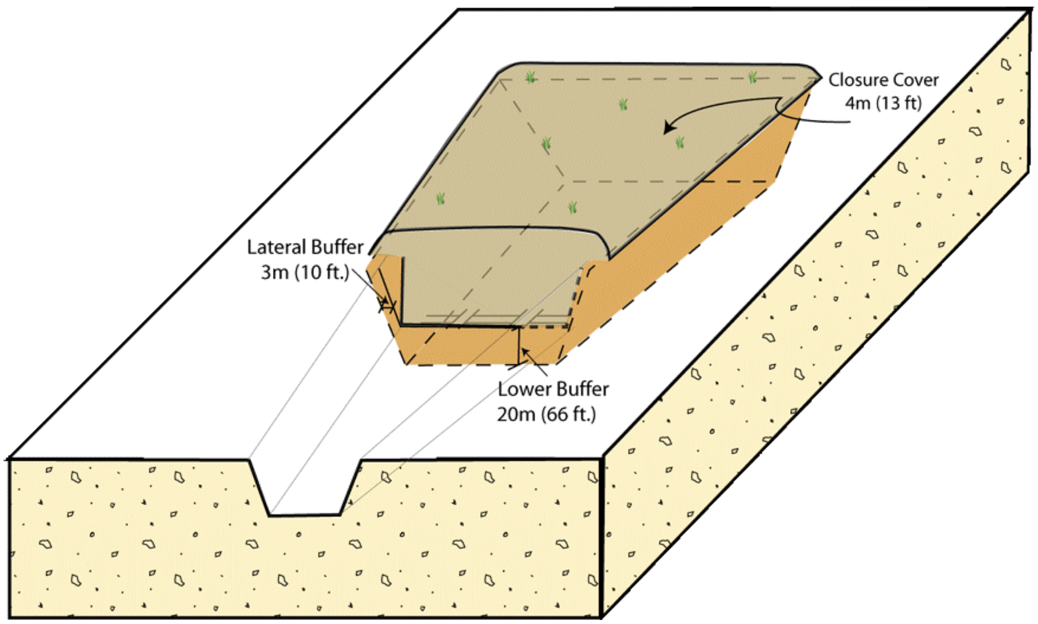


Fig. 4. Natural and engineered components of the alternative landfill system in the arid hydrogeologic setting of the Area 5 RWMS.

front produced from 25 percent wet waste moved 14 m in 50 years; the wetting front produced from 50 percent wet waste moved 18 m in 50 years (14).

Operational Cover. An additional component of the alternative landfill design is a 4.0 m operational cover that provides:

1. Operational safety during active disposal of waste,
2. Protection of the waste zone from surface precipitation events,
3. Prevention of upward migration of contaminants with liquid and vapor-phase water,
4. Prevention of contaminant transport by plant uptake and/or animal burrowing, and
5. Protection from any potential adverse effects associated with activities at adjacent waste disposal units.

Once the operational cover is extended over disposed waste, there is a low potential for leachate generation and no potential for contamination of surface waters. This conclusion is based on the following arguments. First, generation of leachate requires drainage of moisture from the closure cover into the waste zone. Neutron logging data from the non-vegetated cover of the Pit 3 MWDU show no movement of wetting fronts through the standard 2.4 m operational cover to the underlying waste zone during the approximately 10-year interval of the monitoring record (15). Numerical simulations of cover performance predict that drainage through a bare operational cover of 2.4-m thickness will not occur under the Area 5 climatic conditions for at least 12 years; a 3.0-m thick will not drain until 15 years (15, 16). The expected duration of active disposal of mixed waste at the Pit 3 MWDU is five years; no water drainage is expected through the operational cover into the waste zone. Second, should unlikely conditions occur that promote drainage through the cover into the waste zone, the extremely low rate of upward liquid advection (< 0.02 mm/yr) is insufficient to allow leachate to return to the surface and contaminate surface waters. Third, the proposed thickness of the operational cover is 4.0 m, an increased thickness compared to the 2.4 m operation cover now on the inactive eastern part of the Pit 3 MWDU. The thicker cover will lengthen the time required for drainage through the bare cover.

Alternative Landfill Design: Closure Phase

Alternative Closure Cover. The proposed closure cover for the alternative landfill design is a vegetated monolithic-ET cover described in the *Integrated Closure and Monitoring Plan* for the Area 5 RWMS (13). The cover will be composed of screened native alluvium. It will be vegetated to reduce erosion, and to optimize removal of water through ET. The vegetated cover design virtually eliminates drainage into the waste zone. The final cover surface will be merged with closure covers from adjacent waste units and sloped to promote drainage away from the disposal units. The closure cover will be maintained during the RCRA-required 30-year post closure care period. Additional maintenance of the closure cover will occur during the 100-year period of active institutional control of the Area 5 facility required under DOE Order 435.1. Any cracks, fissures, subsidence or erosional changes to the cover will be repaired.

A topic of continuing concern with alternative ET covers is their performance relative to the standard RCRA covers where performance is generally quantified by the control of drainage (1-7). A positive attribute of the expected performance of a vegetated, monolithic-ET cover for Pit 3 is the absence of cover drainage. This performance has been demonstrated through a combination of long-duration lysimeter experiments, monitoring of operation covers over waste cells and hydrological modeling of cover performance using data from the lysimeter experiments and monitoring program (9,15,16). Nearly a decade of observational and experimental data support the conceptual model for the cover and alternative landfill design (9, 15, 16) and permit realistic water balance analyses. These data include:

1. Site-specific soil property data (water content, matric potential, chloride and stable isotope measurements),
2. Multi-year performance data for vegetated and non-vegetated weighing lysimeters,
3. Long-term measurements (nearly three decades) of environmental conditions (precipitation, temperature, humidity, solar radiation, wind speed),
4. *In situ* instrumentation and monitoring of operational covers on waste units in the Area 5 RWMS, and
5. Unsaturated flow modeling using soil moisture and environmental data for model calibration.

To demonstrate RCRA equivalency, numerical modeling of the proposed closure cover was conducted using the Hydrologic Evaluation of Landfill Performance (HELP) model (Version 3.07). Daily simulations were performed for three scenarios (vegetative cover, bare cover, and vegetative cover with doubled annual precipitation). These scenarios were modeled for the proposed alternative cover and for the same cover with the addition of a 36-inch clay liner below the waste zone. The results for the vegetative cover show that both the proposed alternative landfill design and the RCRA design with a liner exhibit zero drainage below the bottom of the

Pit 3 disposal cell over the 30-year model simulation. These results demonstrate that the proposed alternative closure cover (vegetated, monolithic ET cover) shows equivalency with the requirements of 40 CRF 264.310(a)(1). Further, to demonstrate the robustness of the alternative cover design, 30-year model simulations were run with a vegetative cover and a doubling of precipitation. The simulation results show very small quantities of drainage (< 0.13 cm/yr) for the proposed alternative cover design.

LIMITATIONS OF ALTERNATIVE LANDFILL DESIGNS

While alternative landfill designs are supported by the technical communities, there are limitations in the applicability of the designs for some climate settings and soil types. The EPA (6) has published a fact sheet on ET landfill cover systems that includes discussion of both the positive and negative aspects of the alternative design. They emphasize the use of alternative landfill designs, particularly ET cover systems, in settings with arid or semi-arid climates. They further note that precipitation patterns in some regions can limit the effectiveness of alternative cover systems if extreme or closely spaced rainfall events lead to infiltration that exceeds the storage capacity of a cover. Transient drainage through an ET cover can occur even in arid or semi-arid settings if significant precipitation or snow accumulates during winter months when evaporation is reduced and vegetation is dormant. Some alternative cover designs may not adequately restrict diffusion of gases without incorporation of impermeable layers to resist gaseous movement.

Inadequate performance data at field sites deploying ET cover systems is also noted as a problematic topic for acceptance of alternative cover designs. Albright and others (2) reviewed results from 19 sites that have built or tested alternative cover designs. They conclude that varying climatic conditions are well represented in the multiple sites but that ranges in soil types and textures and variability in plant species are not well covered.

The acceptability of model results for cover systems using existing numerical models remains controversial for all cover systems. There are inconsistencies between model results for water balance and process-based numerical models, the models do not simulate preferential drainage pathways and they are generally inadequate for assessing plant activity of native species. Reviews of numerical models of landfill cover performance conclude that nearly all the numerical codes have some limitations and require validation against established databases from multiple hydrogeologic settings (2,17). There is, however, agreement that the preferred approach for establishing cover performance is through evaluation of water-balance lysimeters coupled with long-term meteorological measures and characterization studies of plant communities and hydrologic properties of cover soils (2). Table I summarizes the limitations in ET cover systems listed in the EPA fact sheet (6) and contrasts these limitations with the attributes

Table I. EPA Limitations Evapotranspiration Landfill Cover Systems Fact Sheet, EPA 542-F-03-015	**Alternative Landfill Design, Pit 3 Mixed Waste Disposal Unit**
Applicable only in areas of arid or semi-arid climate	Climate is very arid with extremely high potential evapotranspiration
Limited by local climatic conditions including form and intensity of precipitation/snow and vegetation dormancy	Only trace amounts of snow accumulation; precipitation occurs in two phases with maximum rainfall intensity during the high ET summer months; 2-m thick bare lysimeter shows no drainage in 10 years; storage capacity is very high with thick cover design
Production of landfill gases may limit use of ET covers	Waste streams do not produce significant quantities of gases
Limited field performance data on ET cover percolation	10 years of performance data for bare and vegetated weighing lysimeters with no drainage; no drainage through operation covers with > 5 years of sensor instrumentation; performance data from alternative closure cover demonstration programs (2,7)
Uncertainty and limitations in prediction capability for numerical modeling of cover performance	Performance modeling completed with multiple computer codes (UNSAT-H, HYDRUS-2D; HELP); modeling calibrated to observed lysimeter data; modeling results very favorable (total soil water water < 17.6 cm per meter of soil for bare lysimeter; no drainage for vegetated lysimeter) (9)
Other limitations (not listed on EPA fact sheet): coarse sands with lower water storage capacity than silty sands	4 meter cover thickness compensates for coarse grain-size and lower storage capacity

of the proposed alternative landfill design for the Pit 3 MWDU. The Area 5 RWMS and the Pit 3 MWDU have extremely positive site characteristics for application of an ET cover and the EPA limitations do not restrict the proposed alternative landfill design.

CONCLUSIONS

The alternative landfill design proposed for the Pit 3 MWSU is consistent with the designs for adjacent disposal units in the Area 5 RWMS and uses a defense-in-depth systems approach to protection of surface waters and groundwater. The design consists of multiple natural and engineered design components including:

1. Waste acceptance, operational practices and engineered components of the operation phase to minimize production and migration of leachate.
2. An operational cover of alluvial soils to protect disposed waste prior to closure.
3. A thick vegetated, monolithic ET closure cover for control of erosion and subsidence and for storage of infiltrated water and subsequent removal by natural processes of ET.
4. Lateral and lower buffer zones of native alluvium to restrict and retain movement of water and contaminants.
5. Location in an alluvial basin of the NTS with an arid climate, and deep groundwater.

Performance modeling of the landfill design system shows no expectation of drainage through the cover system or the waste zone. The modeling uses abundant site data from monitoring of operational covers and from long-term lysimeter experiments.

The EPA limitations for use of an ET landfill closure cover are mitigated by the landfill design, the arid climate and the favorable hydrogeologic setting. The composite features of the Area 5 RWMS provide a premier location for deployment of an alternative landfill design.

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