that could percolate into shafts to further reduce the potential for subsurface contaminant transport over time; 2) further reduce erosion potential to limit risk of direct exposure of the waste; 3) further minimize surface transport of contaminants over the next 1,000 years; and 4) further reduce intrusion potential for deep-rooting plants and most burrowing animals.

The conceptual design of an engineered ET cover corrective measure option for MDA H is illustrated in Figure 6. The design is based on research conducted at LANL and Sandia National Laboratories/NM on engineered ET covers (LANL 1998b, Dwyer 2002). The vegetated ET cover was developed explicitly for landfills located in arid and semi-arid climates like Los Alamos. ET covers have been installed at over 36 landfill sites in the southwestern U.S. under the review of the EPA's Technology Innovation Office (the World Wide Web address is http://cluin.org/products/altcovers/usersearch/ lf_search.cfm) and have been found to be a superior alternative to conventional landfill covers in arid and semi-arid climates.

ET covers have been demonstrated to be reliable because they use "natural" climatic and vegetation ET conditions at the site to minimize downward water movement. The proposed engineered ET cover would consist of a topsoil and gravel layer planted with dense, shallow-rooting vegetation to reduce erosion and facilitate soil moisture removal by ET. The non-clay soil would absorb and hold moisture near the surface so that it could be evaporated or transpired. The thin layer of topsoil and gravel would control erosion without compromising the features of the ET cover. The topsoil and gravel mixture would also promote initial plant growth on the cover, further reducing runoff and erosion. Underneath this top layer would be a thick layer (about 3 ft [0.9 m]) of crushed tuff material. Biointrusion barriers, as shown in Figure 6, would be constructed of various materials, including cobbles (about 1 ft [0.3 m] in depth) or a single layer of metal chain-link fencing as has been effectively used before. The biobarrier would be placed immediately over the existing cap of the shafts at MDA H. A cobble barrier would be effective in inhibiting intrusion from most burrowing animals and most deep-rooted plants, whereas metal fencing would be effective against burrowing animals only. The functionality of the existing shaft caps would not be compromised by differential settlement or localized erosion. The engineered ET cover could be easily maintained by adding more topsoil and gravel mixture to areas that settle or erode over time.

Implementation of this corrective measure option would take about five months to implement and would cost about $348,000. An engineered ET cover would be easily constructed. The equipment and material required to construct the engineered ET cover are common construction materials that are readily available. It is estimated that the engineered ET cover could be designed and approved in three months while construction of the cover is estimated to take about two months. As with corrective measure Option 1, a vegetative cover could be established within two years.

2.4.1.3 Corrective Measure Option 3: Partial or Complete Encapsulation and Use of Engineered Caps and an Engineered ET Cover

Corrective measure Option 3 of the Proposed Action would include partial or complete encapsulation of the disposal shafts with the addition of new, engineered shaft caps and an engineered ET cover, along with the implementation of a Long-Term Environmental Stewardship Program as described in Section 2.2. This corrective measure option would enhance the existing shaft caps with additional concrete thickness and utilize currently available commercial encapsulation technologies combined with an engineered ET cover, such as the one described for corrective measure Option 2. Corrective measure Option 3a would include a vertical grout wall encircling the perimeter of the shafts; corrective measure Option 3b would completely encapsulate each individual shaft and would add a bottom cap to each shaft. The primary purpose of corrective measure Option 3 would be physical site security, to reduce the potential for both human and biotic intrusion, rather than for environmental protection. Corrective measure Option 3 could provide limited environmental protection by potentially reducing the migration of contaminants in the shafts by minimizing the potential for water to enter the shafts, thus minimizing the potential for contaminant transport into the surrounding tuff but the degree to which this might occur could not be substantiated. Both partial encapsulation of the shafts and complete encapsulation of the shafts are described in greater detail under corrective measure Option 3a and corrective measure Option 3b, respectively, in the following paragraphs.

The new shaft caps, ET cover, and the partial (corrective measure Option 3a) or complete (corrective measure Option 3b) vertical barrier would be designed to discourage biotic intrusion or human excavation into the disposal shafts over more than 1,000 years. Cement incorporated into an encapsulation matrix and the use of an ET cover and new caps over each of the shafts would make biotic intrusion extremely difficult. This technology would prolong the capability of the existing shaft configurations to inhibit potential intrusion events.

Both partial and complete encapsulation could limit air circulation within the mesa top because these corrective measure options would not allow air to move freely into the shafts. Disrupting air circulation through the natural soil and rock fractures could cause less evaporation to occur within the mesa, resulting in potentially higher shaft moisture levels and nullifying the benefits of the ET cover. Increasing moisture levels in the shafts may also create conditions favorable for the corrosion of uranium metal waste pieces (LANL 2003). Uranium metal can corrode by reacting with atmospheric water and oxygen. Corrosion in the presence of water can result in the formation of uranium hydride that is pyrophoric.[17] The amount of hydride production is correlated to the relative humidity (the higher the relative humidity, the higher the hydride production). Although some hydride production could occur in the shafts, the amount of oxygen present in the shafts is not sufficient to allow or sustain a hydride fire.

Implementation of corrective measure Option 3 would require construction of vertical barriers and an engineered ET cover. The necessary technologies are well established, including specific worker health and safety protocols. As discussed in corrective measure Option 2, an engineered ET cover would be easily constructed. Vertical barriers would be constructed using existing commercial technologies to drill shafts and to force a cement mixture under pressure into the surrounding tuff of the MDA H site. The engineered vertical barriers would be constructed either around the perimeter of the MDA H site and extend to a depth of about 30 ft (9 m) (corrective measure Option 3a) or around each waste shaft individually and extend to a depth of about 65 ft (19.5 m) (corrective measure Option 3b).

[17] Pyrophoric material is a material that will ignite spontaneously when exposed to oxygen. The concern with the presence of pyrophoric materials in the MDA H shafts is that they would ignite if exposed to the atmosphere.

The materials proposed for the vertical barriers in the two encapsulation corrective measure Options 3a and 3b would consist of a mixture of grout[18] or micro-concrete[19] incorporating the tuff already in place at the site. Bench-scale and pilot-scale studies would be required to develop a technologically feasible cement mixture that would meet specifications for construction of the barriers. To be effective over a long period of time, the cement mixture must remain both chemically and physically stable. Because there is the potential for decreased stability of the cement mixture due to chemical disequilbrium with the surrounding tuff, a cement mixture would be chosen to enhance chemical compatibility with the surrounding tuff. Although existing climatic and geological conditions at MDA H would likely cause the surrounding soil to remain dry over the geologic lifetime of the shafts, the cement mixture would be designed to resist water infiltration and minimize leaching as an added precaution to remain optimally protective.

The cement mixture of choice might also be injected into the tuff beneath the shafts from areas outside the shafts so that the material in the shafts would not be disturbed (corrective measure Option 3b). While the necessary slant drilling technologies are well developed to accomplish the drilling of perimeter holes through which to force the cement mixture into the tuff layer beneath the shafts, there is no method developed for determining completeness of the beneath shaft seal. However, since a primary objective of corrective measure Option 3 is to deter human or biotic intrusion, the correct cement mixture formulation would achieve this end, even though a 100 percent bottom seal may not be obtained.

The total time required for design and implementation of this corrective measure option, including bench-scale and pilot-scale tests and construction, would be about one year. An additional two years could be required to establish a vegetative cover. It is estimated that implementation of corrective measure Option 3a (partial encapsulation around the perimeter of the shaft field) would cost about $2,150,000 and that implementation of corrective measure Option 3b (complete encapsulation of each individual shaft, including below the bottom level of the shafts) would cost about $2,550,000. The increase in estimated cost is due to the time required to perform cutting operations at the bottom of the shafts to connect the boreholes surrounding the shafts. Current drilling technology is capable of lateral cutting with either a centrifugal or lateral drill toolset in softer materials such as tuff.

Corrective Measure Option 3a: Partial Shaft Encapsulation with Engineered Caps and an Engineered ET Cover

Corrective measure Option 3a of the Proposed Action would be the implementation of partial shaft encapsulation with new shaft caps and an engineered ET cover. The tops of the shafts would be covered with the placement of an engineered ET cover, as described in corrective measure Option 2, and new engineered shaft caps; a vertical sidewall barrier would be constructed at a predetermined depth and width around the perimeter of the MDA H site. Existing technologies could place the barrier to a depth of about 30 ft (9 m). The thickness of the barrier could be varied from 2 to 3 ft (0.6 to 0.9 m) and may be reinforced with steel. The sidewall barrier would be formed by injecting a cement slurry mixed with powdered native tuff into the subsurface under pressure. The primary intent of the sidewall barrier would be to discourage human intrusion and to restrict plant roots and animals from penetrating the disposal

[18] Grout is composed of cement and additives.
[19] Micro-concrete consists of finely ground cement and sand.

shafts. Figure 7 is a conceptual view of the partial shaft encapsulation corrective measure option for MDA H.

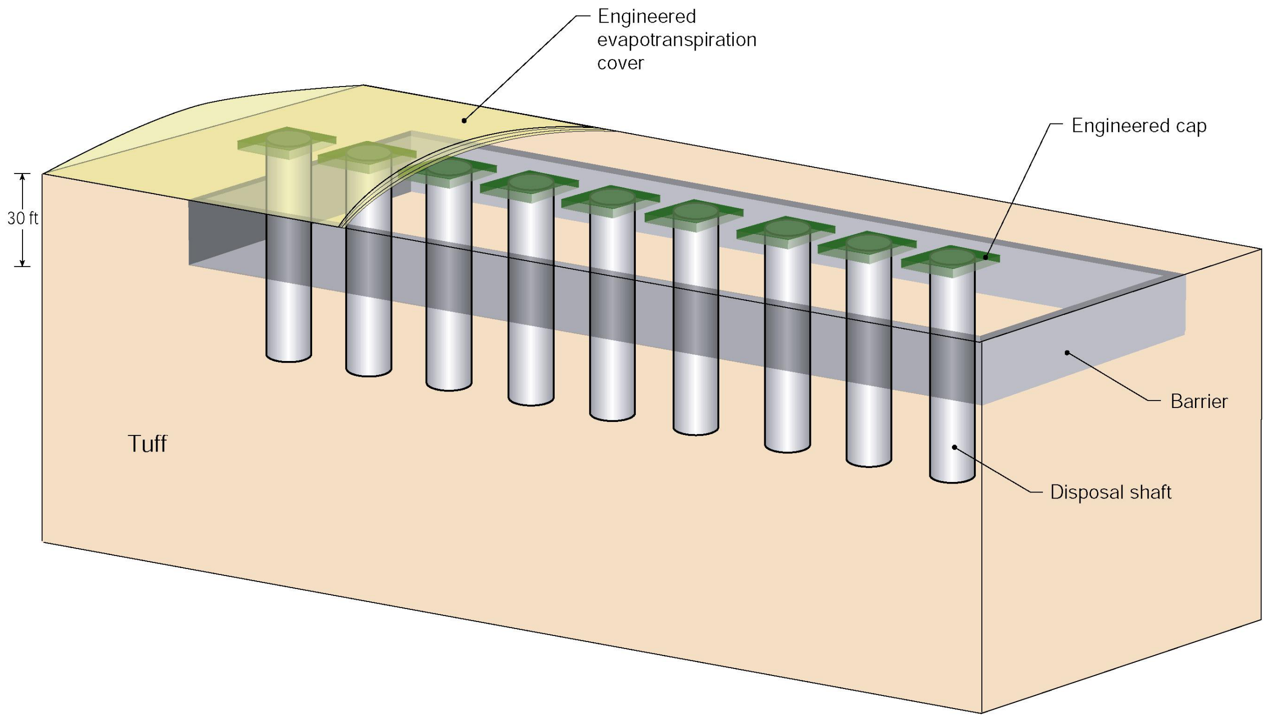

Figure 7. Partial encapsulation with engineered caps and an engineered ET cover.

Shaft 9 would not receive a new cap, as this individual shaft already has a 6-ft (1.8-m) concrete cap. The other eight shafts would have the 3 ft (0.9 m) of tuff that currently makes up part of their caps supplemented with an additional 3 ft (0.9 m) of concrete to form the new engineered shaft caps.

Corrective Measure Option 3b: Complete Shaft Encapsulation with Engineered Caps and an Engineered ET Cover

Corrective measure Option 3b of the Proposed Action would be the implementation of complete encapsulation of each shaft with new engineered top shaft caps and an engineered ET cover, together with bottom caps beneath the shafts. The complete shaft encapsulation corrective measure option (corrective measure Option 3b) would, if successful, offer the maximum protection against plant, animal, and human intrusion and water infiltration, but may enhance water vapor trapping beneath the ET cover. A perimeter side vertical barrier would be constructed around each individual waste shaft at MDA H to a depth of about 65 ft (19.5 m). To form the new perimeter side vertical barrier, interlocking boreholes, 2 to 3 ft (0.6 to 0.9 m) in diameter, would be constructed around the perimeter of each existing waste shaft by using a rotary drilling rig, without actually drilling into or disturbing the contents of the shaft. As each new borehole was completed around the perimeter of an existing MDA H shaft, a cement slurry, or other grout mixture, as appropriate, would be injected into the newly completed borehole by commercially available pressure grouting techniques. A predetermined area below the bottom of each shaft would also be injected with slurry or grout to form a bottom shaft barrier, or cap, using the pressure grouting techniques described for the sidewall boreholes. The borehole cuttings would be stockpiled as crushed tuff for use in the final cap onsite.

The tops of the shafts would be engineered with the placement of a new ET cover, as described in corrective measure Option 2, and new 3-ft (0.9-m) engineered concrete caps. Shaft 9 would not receive a new top cap, as this individual shaft already has a 6-ft (1.8-m) concrete cap, but would receive an engineered bottom cap. Figure 8 provides a conceptual view of the shaft complete encapsulation corrective measure option for MDA H.

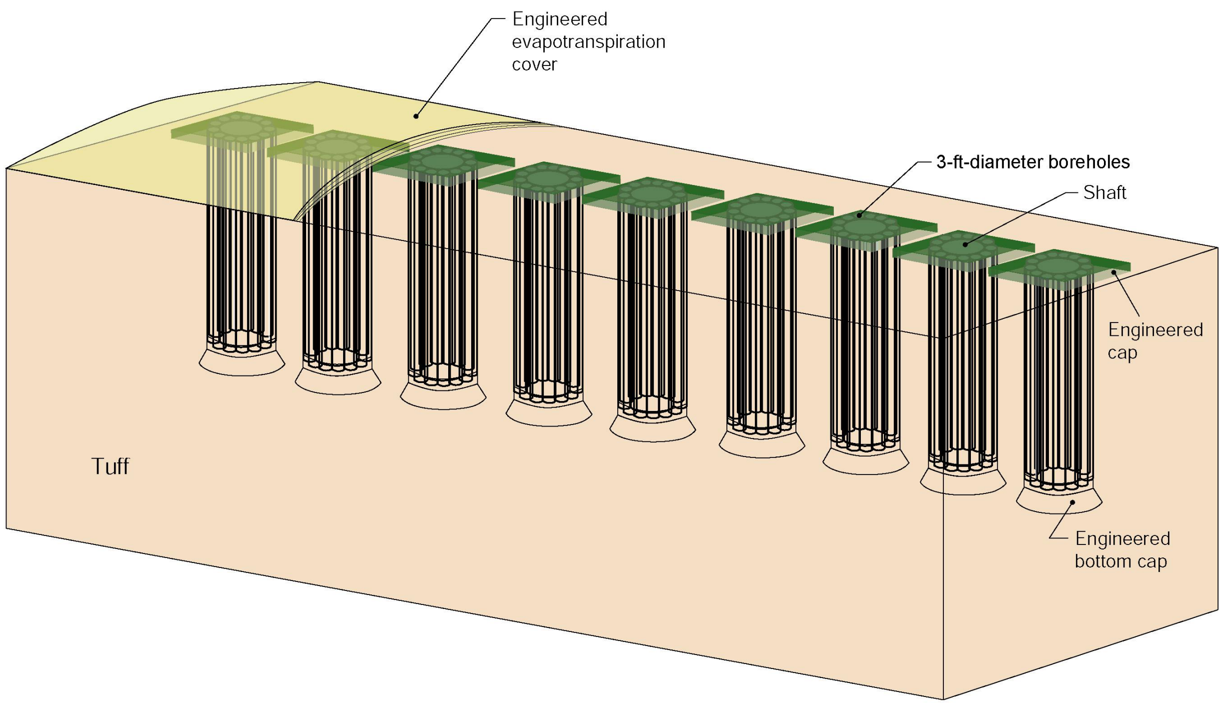

Figure 8. Complete encapsulation with engineered caps and an engineered ET cover.

2.4.2 Excavation and Removal Corrective Measure Options

Corrective measure Option 4 (with maximal offsite disposal) and corrective measure Option 5 (with maximal onsite disposal) of the Proposed Action would include the complete excavation and removal of all waste from MDA H. The information and descriptions provided for both corrective measure Options 4 and 5 are based on conceptual designs for the excavation and removal activities. If NMED were to select either of these corrective measure options, a detailed engineering study, complete hazard categorization and safety analysis would be required for implementing these corrective measure options. Appropriate nuclear safety analyses, authorization basis, security measures, and a site-specific security plan would also be developed, approved by DOE, NNSA, and implemented before site work commenced.

Many of the activities of corrective measure Options 4 and 5 would have to be conducted outside the primary waste management area of MDA H. The specific engineering controls required for the sorting, declassification, and packaging structure would be established during the safety analysis and implemented at the site. Based on the types of materials to be handled, it is expected that high-efficiency particulate air (HEPA) filtration would be required in any waste handling structure.

The conceptual MDA H excavation footprint[20] surrounded by a security fence is shown in Figure 9; a close up of the conceptual MDA H excavation footprint is shown in Figure 10. Implementing either corrective measure Options 4 or 5 would result in disturbing an area of about 10 ac (4 ha).

As shown in Figures 9 and 10, the following construction of support structures and site area modifications would likely be required to implement either of the two proposed complete waste excavation corrective measure options:

- construction of a waste sorting and declassification structure including a storage vault (about 5,600 ft^2 [504 m^2]),
- erection of excavation tenting and moisture protection over the shaft area,
- installation of an enclosed conveyor system (about 100 ft [30 m] long, 14 ft [4.2 m] wide, and 15 ft [4.5 m] tall),
- establishment of an overburden storage area (about 52,000 ft^2 [4,680 m^2]) for soil, tuff, and other material excavated from around the disposal shafts,
- relocation and expansion of the site security fence with controlled access (about 5,000 linear ft [1,500 m]), and
- blading of an access road (about 2,000 ft [600 m] long) between the sorting and declassification facility and the new overburden storage area.

Corrective measure Options 4 and 5 would involve specific waste management requirements that would be incorporated into procedures documented in the security plan and implemented at the site. All excavation and declassification activities would be conducted consistent with this security plan. For site physical security purposes, wastes could be moved only a short distance from the point of excavation to a screening, sorting, and declassification area. Temporary security enclosures could be constructed in the area designed for sorting, declassification, characterization, and packaging operations (Figure 9).

Construction

If either excavation and removal corrective measure option were selected, additional support structures and a new access road could likely be required. After the access road was bladed, the waste sorting and declassification facility would be constructed as needed. This facility would conceptually be located about 60 ft (18 m) southeast of MDA H. Portable toilets could also be installed at this location.

[20] Footprint in this EA refers to the outline or indentation made by excavation activities on the surface of the ground.

In preparation for transporting the wastes removed from the shafts, an enclosed conveyor system about 100 ft (30 m) long, 14 ft (4.2 m) wide, and 15 ft (4.5 m) tall would potentially be installed. The conveyor system could be sized so that it would be large enough to convey the shaft wastes in an inert[21] atmosphere, if required. The proposed conveyor system could consist of a series of glove-box-type units terminating in an inert atmosphere visual inspection station (Figure 11).

Figure 11. Example of a remotely operated dismantling system and inspection station.

As needed, the inspection station could consist of the last 30 ft (0.9 m) of the conveyor system located furthest away from the shafts. If constructed, the remotely controlled visual inspection station would contain manipulator arms, tools, and equipment necessary to determine certain characteristics (such as weight, radioactivity, hazard level, and other important features) of each piece of the wastes removed from the shafts so that a path forward for excavated items, including potentially reactive items that must be further maintained in an inert atmosphere, could be identified. The inspection station could also be equipped with remotely controlled cutters and shredders or other shape deformers, as appropriate, so that dismantling or declassification of certain waste items could be performed. After inspection of the waste was performed, the enclosed conveyance system would move wastes into a packaging and sorting area and, after sorting, move the wastes into appropriate waste containers for recycling, further declassification, or other means of disposal depending on the waste characteristics.

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[21] Inert means unreactive. An inert atmosphere can be obtained through the use of either gaseous or liquid nitrogen.