Department of Energy
Washington, DC 20585

December 5, 2017

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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Deputy Director
Mail Stop T8-F5
Washington, DC 20555-0001

Subject: Field Work Plan for Disposal Cell Cover Study at Lakeview, Oregon, Disposal Site

To Whom It May Concern:

Enclosed is the finalized Field Work Plan, *Effects of Soil-Forming Processes on Cover Engineering Properties, Field Work Plan, Lakeview, Oregon, Disposal Site,* for the joint U.S. Nuclear Regulatory Commission (NRC) /U.S. Department of Energy Office of Legacy Management (DOE-LM) cover study at the Lakeview, Oregon, Disposal Site.

Please call me at (970) 248-6073 if you have any questions. Please send any correspondence to:

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Sincerely,

Richard P. Bush
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Enclosure

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Effects of Soil-Forming Processes on Cover Engineering Properties, Field Work Plan Lakeview, Oregon, Disposal Site

October 2017

U.S. DEPARTMENT OF ENERGY | Legacy Management

Contents

Figures

Appendixes

Abbreviations

ALARA	as low as reasonably achievable
AS&T	Applied Studies and Technology
BCC	Birds of Conservation Concern
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EC	Environmental Compliance
GAC	granular activated carbon
GPS	global positioning system
JSA	Job Safety Analysis
LM	Office of Legacy Management
LMS	Legacy Management Support
LTS&M	long-term surveillance and maintenance
m	meters
m^2	square meters
μR	microroentgen
μrem	microrem
mrem	millirem
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picocuries per gram
pCi/m^2s	picocuries per square meter per second
PPE	personal protective equipment
Ra	radium
RWII	Radiological Worker Level II
SDS	Safety Data Sheet
Th	thorium
TTP	Technical Task Plan
UTV	utility task vehicle

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1.0 Introduction

This study of the Lakeview, Oregon, Disposal Site is part of Project 1 in the Technical Task Plan (TTP) titled *Long-Term Cover Performance Projects* (DOE 2015). Appendix A presents pertinent sections from this TTP.

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for the long-term surveillance and maintenance (LTS&M) of disposal cells for uranium mill tailings throughout the United States. Navarro Research and Engineering, Inc., is the Legacy Management Support (LMS) contractor for LM operations. The long-term protectiveness of disposal cells relies on cover systems that are engineered to limit radon releases, rainwater percolation, and erosion. Natural ecological and soil-forming processes are slowly changing the as-built engineering properties of disposal cell covers in ways that could alter protectiveness and increase LTS&M costs. The details of protectiveness presented in the TTP are also included in Appendix A of this Work Plan. This study is one of four ongoing Applied Studies and Technology (AS&T) projects designed to (1) evaluate the effects of natural processes on the performance of disposal cell covers, (2) investigate options for improving the LTS&M of covers, and (3) inform LM managers of their responsibilities to comply with applicable laws and regulations, maintain long-term protectiveness, and reduce long-term costs.

For all long-term cover performance projects, LM establishes collaboration and cost sharing with other agencies and researchers, fosters education, and disseminates new knowledge through presentations and peer-reviewed publications. The U.S. Nuclear Regulatory Commission (NRC) and LM are sharing the costs for this study. The research group includes scientists and engineers from NRC, the LMS contractor, the University of Virginia, the University of Wisconsin-Madison, the University of California-Berkeley, and the Desert Research Institute. The study will partially fulfill the graduate school requirements for a master of science student and a doctoral candidate. Results will be published in technical journals.

An LMS team was formed to facilitate and assist the research group with the implementation of this study which included preparing this Work Plan, the *Project or Activity Evaluation* (form LMS 1005), *Job Safety Analysis (JSA)* (form LMS 1748), and other documents as required under the LMS *Integrated Work Control Process* (LMS/POL/S11763).

Research Group:

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The study at Lakeview is the subject of this field Work Plan. A map showing the location of the Lakeview site and the general vicinity map is provided as Figure 1. This site is one of several selected for the Project 1 study, which covers a range of cover types, climates, site conditions, and vulnerabilities to change. Relationships between soil morphology and cover engineering properties will be evaluated in test pits in the cover systems and at natural analog sites to understand near-term and potential long-term effects of pedogenesis (the process of soil formation).

This Lakeview study is designed to (1) characterize the morphology of disposal cell cover soils to understand the natural processes that are changing engineering properties and to project the degree of change over decades and millennia, (2) measure the effects of soil-forming processes on radon gas diffusivity and soil hydraulic properties, (3) determine how changes in engineering properties vary with soil depth in cover profiles, and (4) measure and model how these changes influence radon flux rates and rainwater percolation. (See the TTP or Appendix A of this Work Plan for a literature review regarding natural changes in the engineering properties of disposal cell covers and discussions of the relevance and objectives of Project 1 in the TTP.)

Project 1 collaborators selected the Lakeview disposal site as one of the study test sites based on (1) the outcome of a Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I and Title II site screening and ranking process and (2) a recommendation by the research group to compare sites with different climates (DOE 2015). The Lakeview site is an UMTRCA Title I site (https://www.lm.doe.gov/lakeview).

This Work Plan presents an annotated outline of the field workflow for the Lakeview study. The approach used for implementing the project and all personnel will strive to minimize land disturbances caused at this site as a result of conducting this study. The activities proposed in this Work Plan fit within National Environmental Policy Act (NEPA) classes of actions that are categorically excluded for both DOE and NRC. Because Categorical Exclusions do apply, the Lakeview study does not require an Environmental Assessment or an Environmental Impact Statement. See Section 5.1 for additional details.

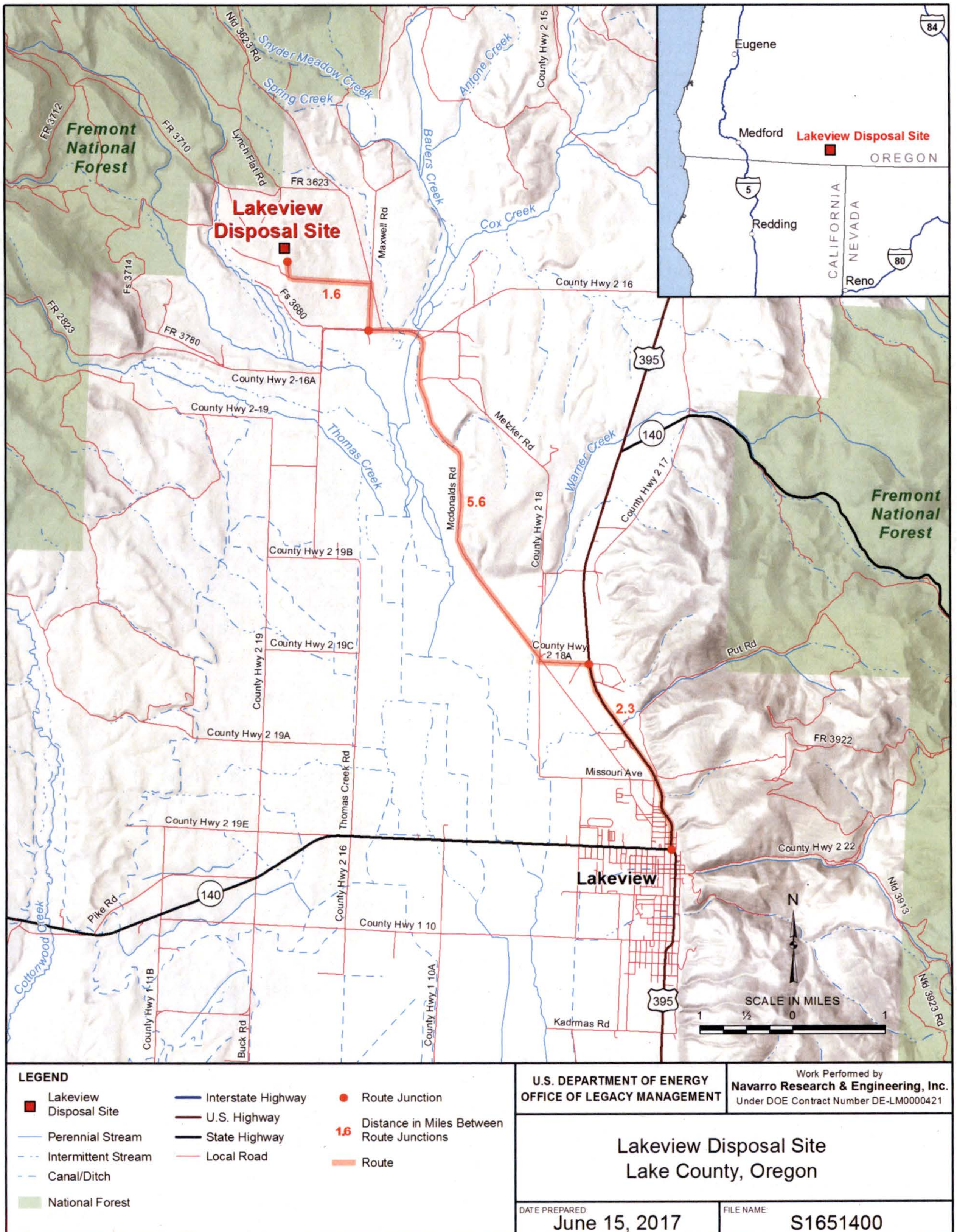

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Figure 1. Vicinity Map of Lakeview, Oregon, Disposal Site

The planned work is not (with concurrence from NRC) considered significant construction or an action or significant repair, primarily due to the limited scale of disturbance. The radon barrier excavation area for sampling and restoration as discussed in this Work Plan amounts to less than 1 square meter (m^2) inside a larger footprint above the radon barrier material at each of the nine potential locations on the Lakeview disposal cell. The total disposal cell cover area at the site is 64,750 m^2; the research will impact less than 0.22% of the cover surface area and less than 0.02% of the radon barrier. Total radon barrier sample volume removed from the site is estimated to be less than 0.4 cubic meter, and it will be replaced with approved borrow source material. In addition, these excavated locations in the radon barrier will be open only for about 1 week and will then be restored and tested for compaction and radon flux to ensure design specifications and regulatory requirements are met.

As requested by NRC, the scope of this Work Plan addresses:

1. Details of the cover restoration process, outlined in Section 2.10, with reference to the original cover design and construction criteria provided in Appendix B
2. Quality of restoration of the cover to its original specifications described in Sections 2.10 through 2.12 and Appendix B
3. The workflow subtasks, annotated to include information regarding the potential for field personnel to be exposed to radiologically contaminated materials (i.e., uranium tailings) presented in Sections 2.3 and 2.7 and associated specific safety and health related requirements, discussed in Section 4.0 (e.g., dosimetry, radon measurements, work zone boundaries, and training requirements)
4. The potential for radiation exposure as a result of the proposed work, in Section 3.0
5. Safety and health concerns (including radiation protection and dosimetry) in Section 4.0
6. Environmental compliance including requirements for driving on the disposal cell and adherence with NEPA, National Historic Preservation Act, and Endangered Species Act statutes, presented in Section 5.0

2.0 Field Workflow

The research group and the LMS team will share responsibility for the fieldwork activities listed below, which are further detailed throughout this section:

- Procure the required equipment and materials
- Locate test sites
- Remove riprap or rock and soil matrix with vegetation at designated locations
- Excavate to remove layers overlying the radon barrier
- Measure radon flux through the radon barrier
- Perform large block sampling of the radon barrier
- Measure radon flux on the upper surface below the radon barrier
- Perform sampling of the radon barrier with thin wall sampling tubes

- Perform soil morphology sampling of the test pit sidewall
- Restore the radon barrier
- Measure radon flux on the restored radon barrier
- Replace layers overlaying the radon barrier
- Conduct select study objectives at analog test sites

2.1 Required Equipment and Materials

Before intrusive work, the following equipment and materials will be on hand (the responsible team or group is shown in parentheses):

- Survey equipment Global Positioning System (GPS) (LMS team)
- Stakes, pin flags, or paint to mark test area boundaries and tarps to cover test areas and place on excavated materials (LMS team)
- Measuring tapes to measure and document test pit dimensions and layer and sample depths from surface reference points (research group and LMS team)
- Mini-excavator, rakes, shovels, or other equipment to clear and repair cover material layers (LMS team)
- Radon flux test equipment (research group)
- Soil physical and hydraulic property testing and sampling equipment (research group)
- Soil morphology characterization and sampling equipment (research group)
- Radon barrier materials from an approved borrow source, as needed (LMS team)
- Compaction equipment and mobile water tank (LMS team)
- Compaction testing equipment (LMS team, geotechnical subcontractor)

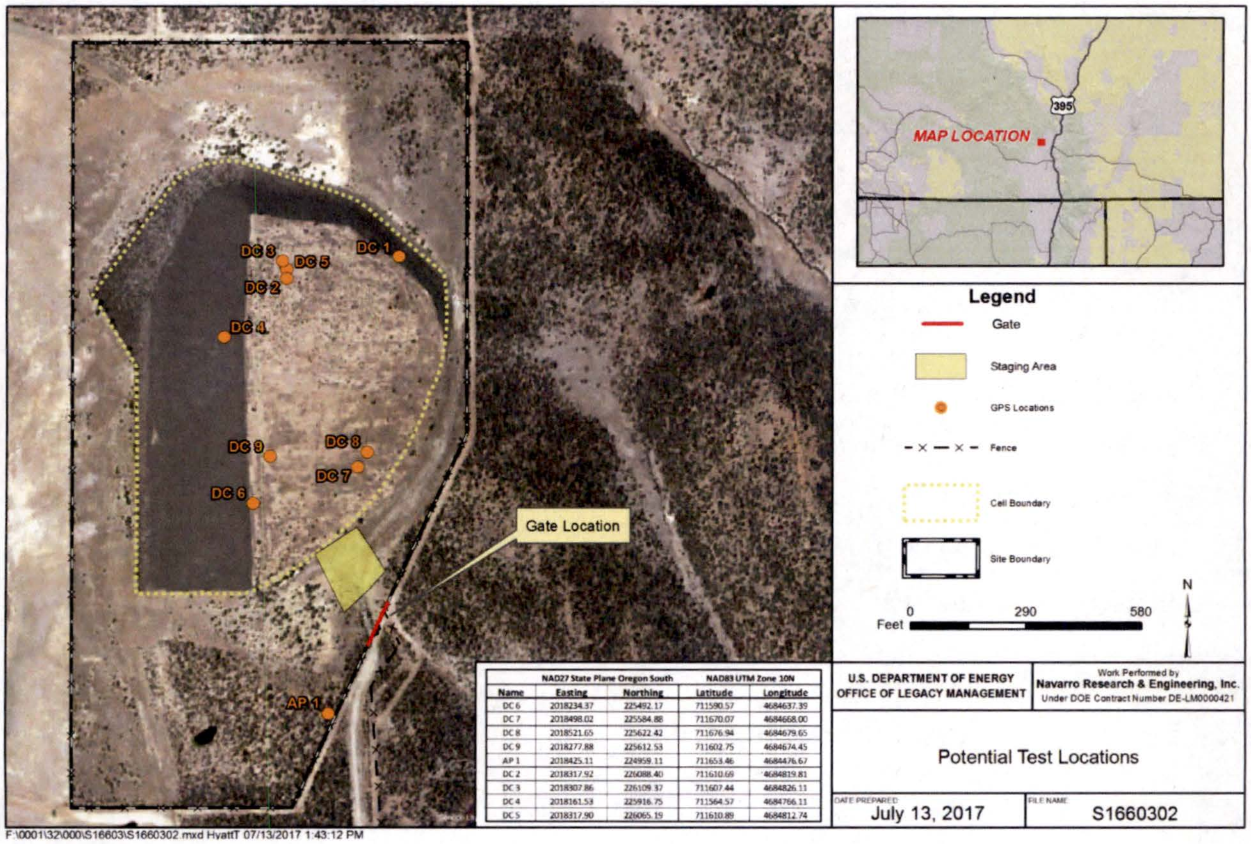
2.2 Locate Test Sites (research group)

Five to nine test pit locations will be chosen for study on the disposal cell cover. The actual number tested will depend on the time required to compete and restore each test pit. The research group has funding to be in the field for approximately 1 week. Test pit locations will be selected that represent a range of cover conditions.

Examples of preferred test conditions are:

1. Areas likely to have the most pedogenesis and greatest seasonal drying (i.e., areas with abundant vegetation rooted in the radon barrier)
2. Areas likely to have the least pedogenesis and least seasonal drying (i.e., areas on the top slope with sparse vegetation or areas on the side slope with a rock riprap layer at the surface)
3. Areas with different soil sources and types
4. Areas where tunneling insects and burrowing mammals have created channels and may have brought contaminated material to the surface

Figure 2 depicts nine potential test sites on the disposal cell cover (DC-1 through DC-9). The actual study locations may change upon further field reconnaissance. The analog test location (AP-1) is off the disposal cell but within the site boundary, as shown in Figure 2. A cultural resources survey was conducted at the analog test location that encompassed the area within a 30-meter radius of the marked location. The survey was required because AP-1 will be located within a previously undisturbed area on the site; AP-1 must be excavated within the surveyed area. (See the discussion in Section 5.2 for additional information.) Cultural resources surveys were not required at the test locations on the disposal cell. The LMS team will locate with GPS, stake, and record the boundaries of all test pits.



	NAD27 State Plane Oregon South		NAD83 UTM Zone 10N	
Name	Easting	Northing	Latitude	Longitude
DC 6	2018234.37	225492.17	711590.57	4684637.39
DC 7	2018498.02	225584.88	711670.07	4684668.00
DC 8	2018521.65	225622.42	711676.94	4684679.65
DC 9	2018277.88	225612.53	711602.75	4684674.45
AP 1	2018425.11	224959.11	711653.46	4684476.67
DC 2	2018317.92	226088.40	711610.69	4684819.81
DC 3	2018307.86	226109.37	711607.44	4684826.11
DC 4	2018161.53	225916.75	711564.57	4684766.11
DC 5	2018317.90	226065.19	711610.89	4684812.74

Figure 2. Potential Test Locations

2.3 Remove Riprap on the Side Slope or Rock and Soil Matrix with Vegetation on the Top Slope at Designated Test Pit Locations (LMS team)

The engineered cover layers on the top slope of the disposal cell consist of a rock and soil matrix with vegetation, a bedding layer, and a radon barrier; the side slope consists of rock riprap, a bedding layer, and a radon barrier. As-built cross sections of these layers and material descriptions are included in Appendix B. Figure 3 and Figure 4 illustrate sequential schematics (showing both plan and cross-sectional views) depicting proposed field activities that include excavations, sampling, monitoring, and restoration (as described in subsequent sections) for both

the top slope and side slope, respectively. Profile measurements, and the removal of the uppermost protective layer (i.e., rock and soil with vegetation, or rock riprap) for both the top slope and side slope are described below:

- Before removal of cover layers, a small core will be removed with a hand auger. Cuttings will be monitored and measured to help identify and verify layer depths and contacts before test pit excavations.
- On the top slope, the rock and soil matrix with vegetation (estimated to be about 12 inches thick) will be removed, exposing the underlying bedding layer in a 16 m^2 or smaller area for each test location. The rock and soil matrix will be stockpiled separately from vegetation on tarps or similar materials for replacement at the conclusion of monitoring and sampling. Tarps will be placed over the stockpile to reduce drying and prevent precipitation from mobilizing the sediment or altering the moisture content of the materials.
- On the side slope, riprap (about 12 inches thick) will be removed, exposing the underlying bedding layer in a 16 m^2 or smaller area for each test location. The riprap will be stockpiled on similar material for replacement at the conclusion of monitoring and sampling.
- An undisturbed vertical face will be left on at least one side of each test pit. Soil morphology will later be characterized on an undisturbed cover soil profile along this excavation face.

2.4 Excavate to Remove Layer Overlying the Radon Barrier (LMS team)

The bedding layer depicted in Figure 3 and Figure 4 will be the next layer removed on both the top slope and side slope, exposing the top of the underlying radon barrier. The following actions will complete this subtask.

- The bedding layer (about 6 inches thick) on both the top and side slopes will be excavated, exposing approximately a 16 m^2 area of the radon barrier's upper surface.
- The removed bedding layer material will be stockpiled on tarps for restoration at the conclusion of sampling. Tarps will be placed over the stockpiles.
- The radon monitoring chambers will be immediately placed over newly exposed areas of the radon barrier and secured. Tarps may be used to limit drying of the radon barrier (or wetting of the barrier, if it rains) between the time the LMS team removes the overlying material and the research group performs testing.

2.5 Measure Radon Flux Through the Radon Barrier (research group)

Radon flux on the upper surface of the radon barrier will be measured at each location with various-sized radon flux chambers (large [1.5m × 1.5 m], medium [0.4 m × 0.85 m], small [0.3 m diameter], and extra-small [0.15 m diameter]). Figure 3 and Figure 4 illustrate proposed measurement locations in both plane and cross-sectional views. Time 1 shown in these figures depicts the measurements in this section; subsequent and sequential sections are depicted as Time 2 through Time 5. Figure 5 shows a typical radon monitoring equipment configuration on top of the radon barrier; including flux chambers of various sizes that are similar to those planned for this study.

Duplicate measurements may be conducted at test pits. The large-scale chambers are adapted from the inner "ring" of sealed double-ring infiltrometers that were used previously to measure

the effects of pedogenic processes on soil hydraulic properties. The large scale is necessary to ensure that radon flux measurements are made over an area sufficiently large to encompass radon movement through macropore structure (caused by soil-forming processes) in the radon barrier. Flux chambers will be sealed to the surface of the radon barrier, with bentonite, and soils that surrounded each flux chamber will be replaced to ensure a continuous surface boundary (DOE 2015). Radon flux measurements will employ the use of granular activated carbon (GAC) canisters for lab analysis and Rad7 real-time monitoring equipment also shown in Figure 5 (Benson et.al. 2017). After measurements are complete (typically overnight) all monitoring equipment will be removed for subsequent test pit activities.

2.6 Perform Large Block Sampling of the Radon Barrier (research group)

Soil physical and hydraulic properties will be measured at multiple vertical intervals within the radon barrier to test hypotheses about depths of soil-forming processes and effects on percolation rates. After the completion of radon flux tests and the removal of chambers in the test pits, large-scale (0.36 m diameter) undisturbed radon barrier block samples will be obtained from each test pit for testing. Blocks are obtained by excavating a pedestal of the intact radon barrier and encasing it in a (0.25 m length) beveled PVC pipe. The area of the excavation will be about 1 m^2 down to the base of the radon barrier. The thickness of the radon barrier (from the top of the radon barrier to contact with potentially contaminated materials below) is expected to be approximately 18 inches on the cover top slope and side slope. Before excavation and sampling, the radon barrier thickness at each test location will be checked against as-built maps from the *Lakeview, Oregon Final Completion Report* (DOE 1991) and against the small core described in Section 2.3. Actual contact depths will be determined using indicators of soil color, texture, moisture content, radon monitoring, and other indicators observed by the soil morphologist. Extra care will be taken to not excavate beyond the radon barrier and into any underlying potentially contaminated materials (uranium mill tailings) directly below by closely monitoring and scanning for radioactivity in the soil boring and test pit. If monitoring and scanning indicate radiologically contaminated materials are being encountered, work zone restrictions described in Sections 4.4 and 4.12 will be put in place. The Time 2 schematic shown in Figure 3and Figure 4 depicts the location of the block sample within each test pit described in this section. Figure 6 shows a typical test pit, a large block sample, and soil stockpiles, as well as a thin tube sample being collected (as discussed in Section □

Large block sampling sequential tasks:

- The location will be marked on the radon barrier to obtain 0.36-m-diameter block samples.
- Access and safety controls will be installed, as required, if depths exceed 4 feet (which is not expected) or if a physical or radiological hazard exists.
- The depth of the radon barrier will be determined, and extra care will be taken to not excavate beyond the radon barrier.
- The block samples of the radon barrier will be excavated and residual materials will be placed on a tarp or adjacent radon barrier surface.

The block samples will be removed and scanned for radioactivity; no radioactive waste materials are expected within the radon barrier nor will any be removed or shipped.

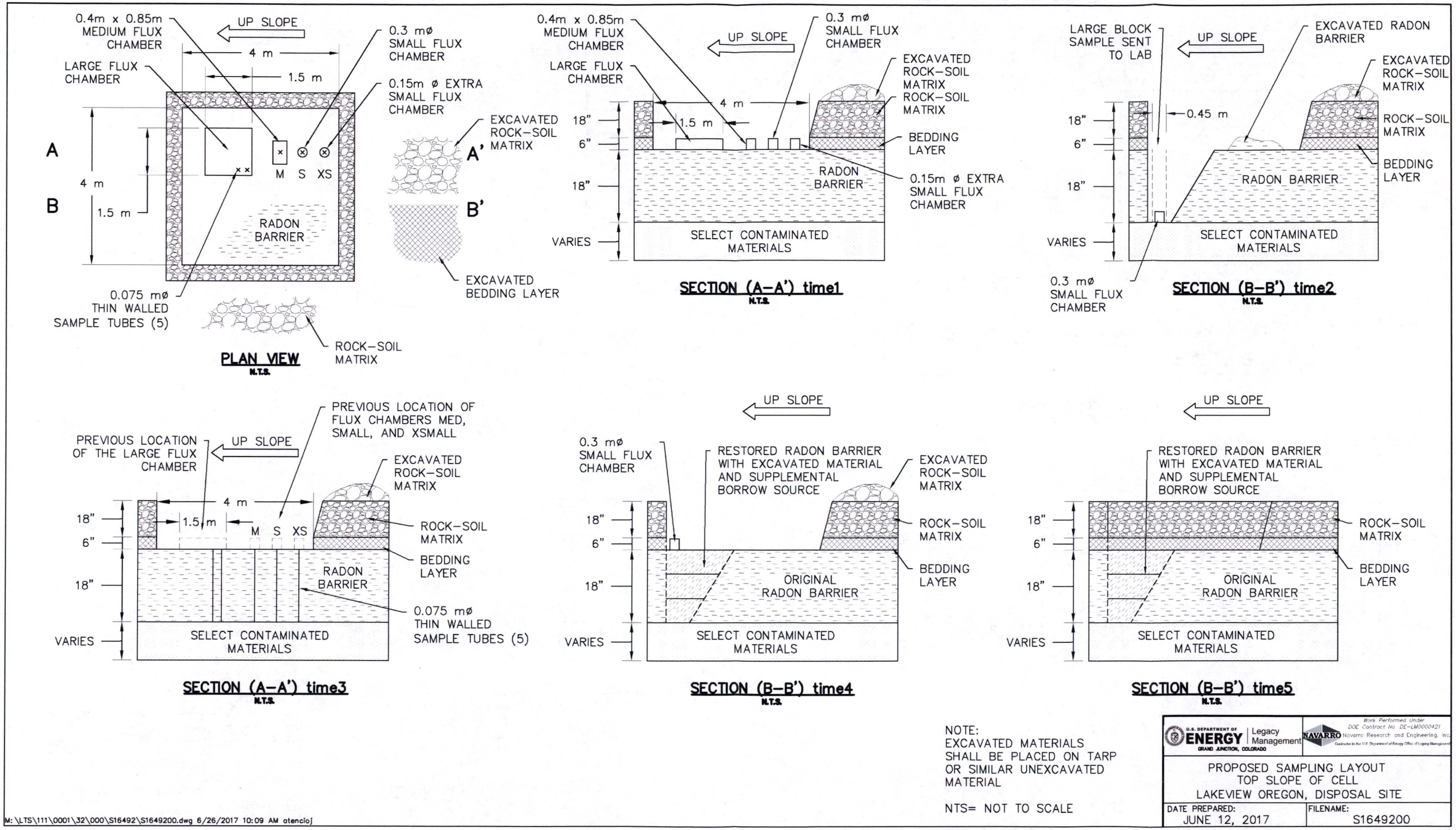


Figure 3. Proposed Sampling Layout, Top of Cover Locations

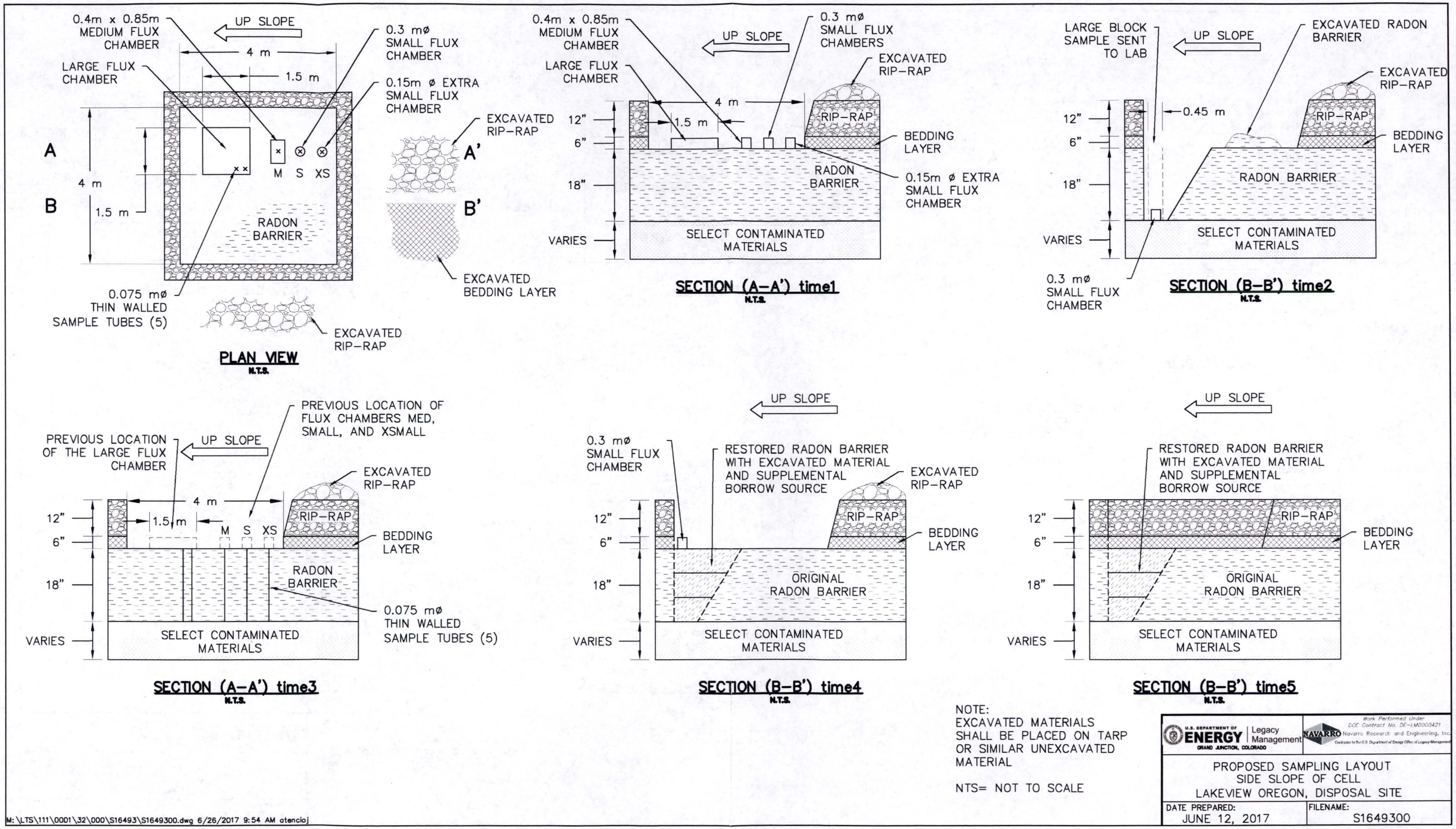


Figure 4. Proposed Sampling Layout, Side Slope Locations

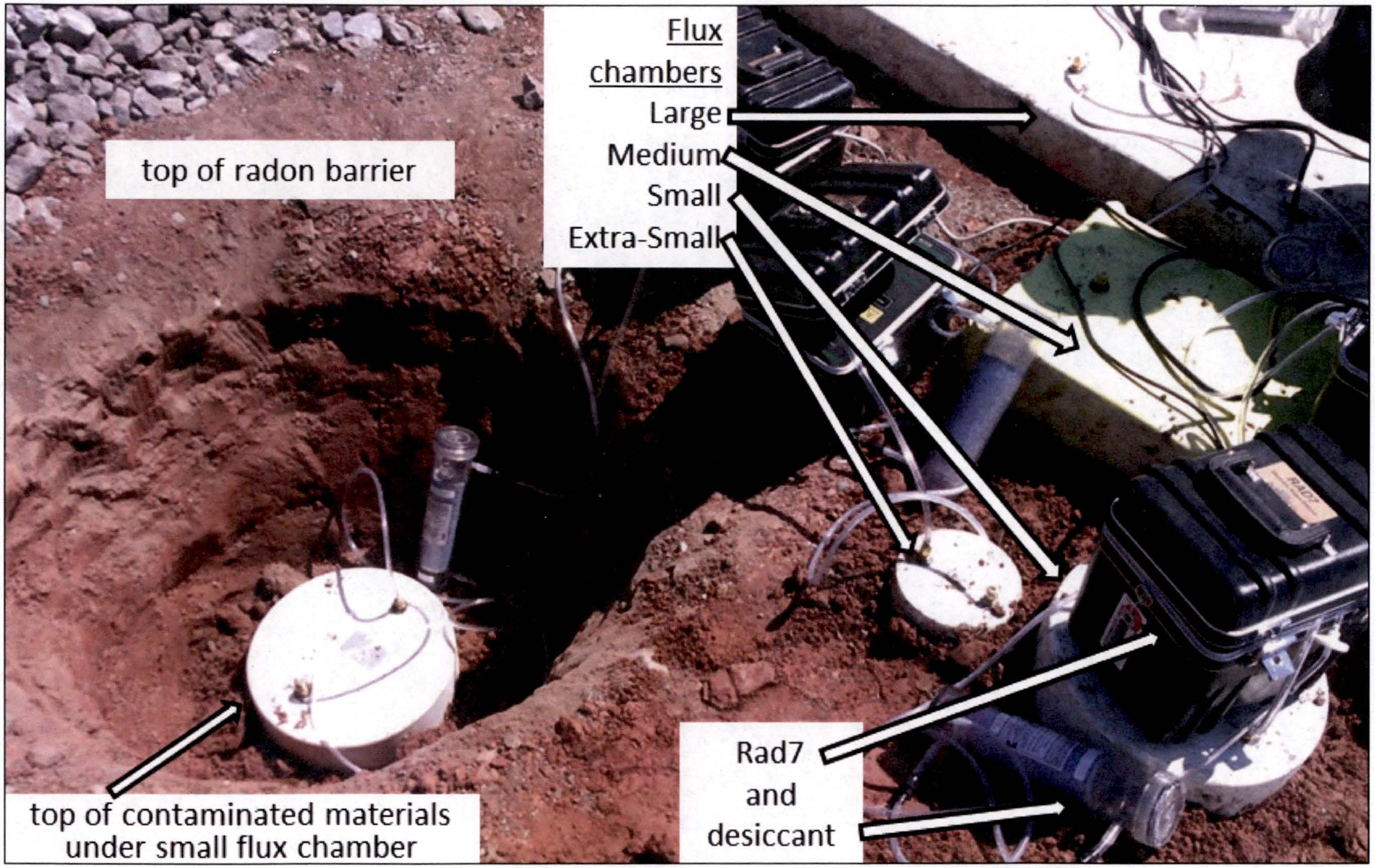


Figure 5. Radon Flux Monitoring Setup

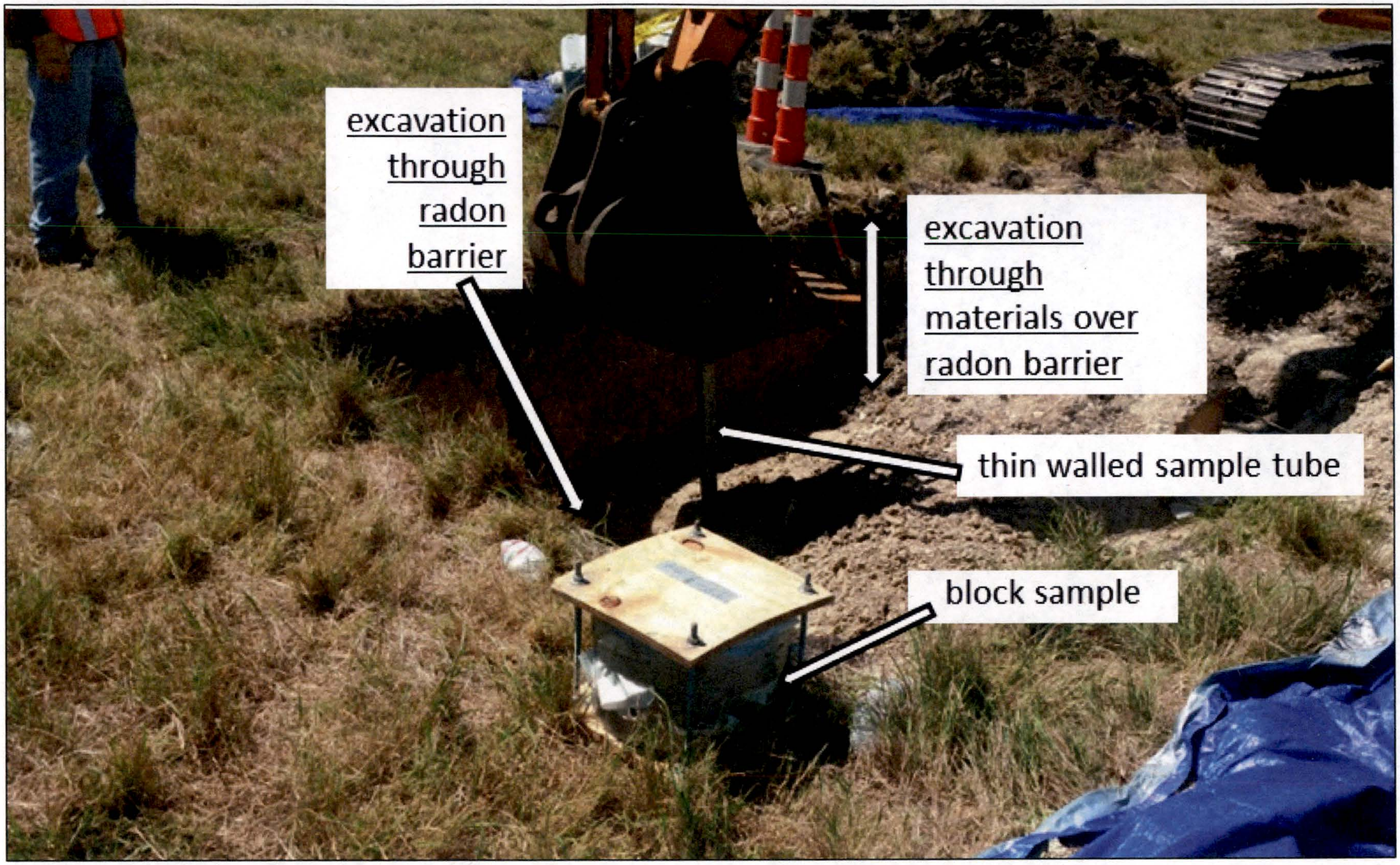


Figure 6. Block and Thin-Tube Sampling

- Block samples will be packaged for shipment to the University of Wisconsin-Madison geotechnical engineering laboratory.
- Excavation will be continued (with radiological personal protection measures in place) to expose the surface of the encapsulated materials immediately below the radon barrier that may or may not be contaminated.

2.7 Measure Radon Flux on Surface Below Radon Barrier (research group)

After block sampling of the radon barrier is complete and the excavation is extended down to the surface of the encapsulated materials immediately below the radon barrier, radon flux will be measured on the surface of the encapsulated materials. The surface immediately below the radon barrier, which is often low-activity soil, will be measured using a small-scale conventional flux chamber. The Time 2 schematic shown in Figure 3 and Figure 4depicts the measurements described in this section. The left side of the photo in Figure 5 also depicts the measurement from this surface.

Subtask details to be performed as presented in Benson et.al. (2017):

- Install and seal the test chamber at each site.
- Perform radon testing.
- Remove the radon test chamber.
- Replace several inches of radon barrier on the exposed surface to eliminate potential exposure during subsequent work activities.

2.8 Perform Sampling of the Radon Barrier with Thin-Wall Sampling Tubes (research group)

Thin-wall sampling tubes (0.075-m-diameter) will be advanced into the radon barrier where radon flux chambers have been removed to obtain continuous undisturbed samples. Sample tubes will be collected beneath the previously measured flux chamber locations that were installed on the top surface of the radon barrier. The Time 3 schematic shown in Figure 3 and Figure 4 depicts sample collection described in this section, and Figure 6 shows the actual collection of these sampling tubes at a previous study location.

Subtasks:

- Mark the location on the surface of the radon barrier to obtain continuous samples with thin wall sampling tubes.
- Perform thin-tube sampling no deeper than the base of the radon barrier observed in adjacent excavation for large block samples, using the mini-excavator to push and remove tubes.
- Scan for radioactivity; no radioactive materials are expected within the radon barrier nor will any be removed or shipped. Package the samples for shipment to the University of Wisconsin-Madison geotechnical engineering laboratory.

2.9 Perform Soil Morphology Sampling of the Test Pit Sidewall (research group)

The research group will characterize and classify the morphology of engineered cover profiles and natural analog soil profiles to (1) understand the pedogenic processes responsible for soil development that might impact soil engineering properties and (2) quantify the degree of change that might occur on decade- and century-long time scales over the design life of cover systems. The morphology of soil profiles in the cover test pits (radon barrier and overlying layers) and at a soil analog site (undisturbed profiles at the radon barrier borrow site) will be characterized.

Characterization will include conventional soil survey methods, digital soil surveys, thin-section micromorphology, and microbial community assay nutrient cycling. The morphology of analog soil profiles will provide information about how soil-forming processes might continue to change the cover in the long term (from hundreds to thousands of years). Within the test pits, a clean, undisturbed profile face will be exposed on a side of the excavation. For analog soil characterization, a cut face at the edge of the radon barrier borrow area will be cleaned to expose undisturbed soil profiles. Approximately 1 cubic foot of cover materials will be removed from each cut face for chemical, physical, and biological analysis. Soil morphology characterization and sampling will take about 4 hours per soil profile.

Subtasks:

- Hand-dig clean profile faces along undisturbed edges of the excavations where block samples were removed and on cut faces of the radon barrier borrow area.
- Characterize morphology and take morphometric measurements.
- Retrieve samples for chemical, physical, and biological analysis.
- Package samples for shipment to the University of California-Berkeley soil morphology laboratory.

2.10 Restore the Radon Barrier (LMS team, geotechnical subcontractor)

The radon barrier will be restored to the original designed specifications presented in Appendix B. Soil will be retrieved from an appropriate borrow source at the Lakeview site to supplement stockpiled material from the cover excavations. Figure 3 and Figure 4 depict the restoration described in this section (see Time 4 schematic). Borrow material will be sampled and characterized by a geotechnical engineer to verify that properties meet the original design specifications. Borrow materials shall also meet original specifications described in Appendix B.

Radon barrier materials will be replaced to meet the original design specifications for lift heights and compaction as described in Appendix B and Appendix C. Compaction will be achieved with a mechanical jumping jack-style compactor or rammer unless otherwise directed by this Work Plan or approved by the project engineer discussed in Appendix C. Compaction will be tested for density and moisture content using a nuclear moisture density gauge (ASTM D2922-81 and D3017-78) or sand cone and moisture content tests (ASTM D1556-82 and D2216-80) in compacted lifts. Radon barrier restoration will be monitored for moisture and compaction compliance by a geotechnical subcontractor during material replacement. Detailed notes and

photographs of the restored test pits and the process will be documented for inclusion in a test pit restoration report.

Subtasks:

- Acquire supplemental radon barrier soil from the borrow source while scanning for radioactivity.
- Verify borrow material meets the original design specifications (geotechnical subcontractor).
- Moisture-condition the radon barrier soils; a rake and sprayer may be necessary.
- Rebuild the radon barrier in each test pit, meeting original designed requirements for lift height and compaction.
- Test compaction with a nuclear moisture density gauge or sand cone and moisture content tests (geotechnical subcontractor).

2.11 Measure Radon Flux on Restored Radon Barrier (LMS team)

After radon barrier restoration is complete, radon flux will again be measured (using the procedures described in Section 2.5) on the surface of the reconstructed radon barrier with a small-scale conventional flux chamber over GAC canisters for lab analysis. The Time 4 schematic shown in Figure 3 and Figure 4 also depicts monitoring described in this section.

Subtasks details to be performed as presented in Benson et.al. (2017):

- Install and seal the test chamber at each site.
- Perform postrestoration radon testing.
- Remove radon test chamber and send GAC canisters for lab analysis.

2.12 Restore Layers Overlying Radon Barrier (LMS team)

The previously removed layers (which can include rock riprap or rock and soil matrix with vegetation, as well as bedding layers) will be restored to the original designed specifications. The Time 4 schematic shown in Figure 3 and Figure 4 also depicts the restoration described in this section.

Each restored area will be left slightly elevated to allow for consolidation over time. The surface of the replaced rock and soil matrix with vegetation will be left in a rough, pitted condition to promote water retention and seed germination. Details of these subtasks are presented in Appendix C.

Subtasks:

- Rebuild the bedding layer in each test pit, meeting as-designed requirements for material, lift height, and compaction.
- Replace rock riprap on side slopes as required to meet the original designed condition.

- Replace rock and soil matrix with vegetation on top slope and compact with a rammer to force the soil into the voids. Compaction shall be deemed complete by visual inspection when all surface voids in the rock are completely filled. No testing will be required.
- Hand-broadcast and rake in approved seed mixture.
- Run tracked mini-excavator over the area.
- Arrange to check growth of seed mixture in subsequent site visits and annual inspections.
- Monitor for longer-term subsidence at the restored test locations, and repair as necessary.
- Document details of all restoration and monitoring performed to demonstrate compliance for inclusion into a poststudy cover restoration report.

2.13 Conduct Select Study Objectives at Analog Test Site (LMS team, research group)

Workflow at the analog test site will generally follow those steps outlined in Sections 2.3 and 2.4. The analog test site must be within a 30-m radius of the location shown in Figure 2 that was cleared for excavation with respect to the cultural resources survey. Depths of the excavation will be determined by conditions encountered in the field, and proper benching of the excavation will take place if the test pit exceeds 4 feet in depth. Tasks identified in Sections 2.5 through 2.9 may be completed at the analog test site if conditions warrant.

The analog test site will be backfilled with excavated materials in approximately the same order as they were removed to help maintain existing soil profiles. No material will be brought in to replace minor volumes removed as samples. The analog test site backfill will be compacted with the weight of the mini-excavator, which may be supplemented with the rammer compactor. The same seed mixture and subtasks identified in Section 2.12 will also be performed at the analog test sites.

3.0 Potential Dose

3.1 Radon Exposure

Title 10 *Code of Federal Regulations* Part 835 (10 CFR 835) contains several requirements involving occupational exposure to radon and radon progeny that proved impractical to implement. The major problem is that the regulation presumes it would be practical to distinguish occupational exposure to radon and radon progeny from background exposure to the same radionuclides. Several provisions of the regulation involved recordkeeping and the triggering of additional measurements based on this presumption. In practice, it proved impractical to separately measure occupational exposures and background.

Therefore, DOE was granted an exemption from several radon-related provisions of 10 CFR 835 on February 9, 1995. The exemption eliminated the need to attempt to separately measure occupational exposures and background. In the future, background and occupational exposures will be combined, and the exemption raises thresholds beyond which certain monitoring and air sampling is required. However, during LMS projects similar to this Lakeview study, radon

monitoring was performed using track etch dosimeters. Based on these sample results, it has been determined that remedial actions for uranium mill tailings present little potential for measurable human internal radon exposure.

Although the DOE radon dose exemption provides relief from inherent problems with radon dose assessment, DOE is committed to keeping individual and collective doses as low as reasonably achievable (ALARA) using the following concepts:

- **Time:** Reducing the time spent in a radiological area
- **Distance:** Increasing the distance between an individual and the radiation source
- **Shielding:** Increasing the amount of shielding around a radiation source

The LMS contractor will also implement practical radiological controls including real-time radiological dose monitoring, establishing physical boundaries, posting signs identifying area-specific hazards, monitoring for loose surface contamination, suppressing dust, controlling area access, and using personal protective equipment (PPE) appropriate for the work being conducted.

3.2 Thorium and Radium Exposure

To develop a thorium and radium conservative exposure dosage estimate, a scenario was developed for this same study conducted at a previous site (Falls City, Texas, Disposal Site). In that scenario, LM assumed that the main work over the tailings pile with the radon barrier removed would result in an average 70 picocuries per gram (pCi/g) of thorium-230 (^{230}Th) and 25 pCi/g of radium-226 (^{226}Ra) (This is far greater than any measurement LM has recorded in other mill tailings disposal cells). A worker right at the point of penetration would be the most exposed worker, assuming he or she works for 40 hours per week (this calculation is compared against the allowable limits based on a yearly exposure). An exposure pathway for this worker would be gamma radiation exposure from soils contaminated with ^{230}Th and ^{226}Ra.

Measurements have shown that the gamma exposure rate ranges from 0.5 to 2.0 microroentgen (μR) per hour per pCi/g. These measurements are very conservative. Also, although μR and microrem (μrem) are two different measurements, for gamma rays the units are considered equivalent; 1 μR is equal to 1 μrem. If a worker received the maximum value for a 40-hour exposure time, the result (averaged over a year) would be an increase of 5.6 millirem per year (mrem/year) for that worker. This calculation is extremely conservative, as the exposure time for an individual worker during this project will be significantly less than 40 hours. In addition, during construction of the disposal facility, less-contaminated material was placed on top of the more-contaminated tailings. Therefore, once an exploratory hole at a test location is created, the activity concentration is expected to be considerably less than 70 pCi/g for ^{230}Th and 25 pCi/g for ^{226}Ra. To ensure exposure ALARA is maintained, all activities that have a potential for radiological exposure will be continuously monitored by a qualified radiological control technician.

Another pathway that may be considered for the worker is the intake of contaminated soils and radon by inhalation. A dusty work environment would normally result in less than 200 micrograms per cubic meter of respirable dust. Assuming a breathing rate of 20 liters per minute, a ^{230}Th concentration of 70 pCi/g, a ^{226}Ra concentration of 25 pCi/g, and an

exposure time of 40 hours per year, the worker would be expected to receive a committed effective dose equivalent of approximately 0.2 mrem/year (by comparison, the annual limit for occupational radiation workers is 5000 mrem/year). Factors used to assess committed dose equivalent per unit intake via inhalation were taken from *The Health Physics and Radiological Health Handbook*. Radon and radon progeny concentrations in air can be measured and recorded.

Results from track etch dosimeters worn by fieldworkers in 2016 for this study conducted at the Falls City disposal site and the Bluewater, New Mexico, Disposal Site all came back as minimal dose equivalent reported. Dose tracking logs for other site workers during the study at the Bluewater site ranged between 480 and 620 µrem for the week.

Based on these assumptions, no significant radiological risks are anticipated with this work activity. However, all work will again be monitored and recorded to ensure that ALARA principles are enforced.

4.0 Safety and Health

This section describes the project safety and health requirements. All work shall be conducted in accordance with safety regulations promulgated by state and local agencies and DOE regulations that are contained in the LMS *Safety and Health Manual* (LMS/POL/04321).

Workers are responsible for identifying safety concerns, potential hazards, or unsafe conditions and notifying management. Each worker has the right, responsibility, and authority to report unsafe or environmentally unsound conditions or practices and to stop work activities without fear of reprisal. Unsafe workers, including workers who do not wear required PPE, will be required to leave the site.

4.1 Job Safety Analysis

All LMS team and research group workers shall read, sign, and adhere to the hazard controls specified in the approved JSA. Workers shall not perform any work not covered by the JSA or for which the JSA does not provide adequate protection. Workers shall follow all requirements stated in the JSA, such as heat stress evaluation and monitoring. The contractor Safety and Health representative can modify the JSA to reflect changed conditions or equipment as needed or as requested by a worker.

4.2 Training Requirements

Workers are responsible for performing tasks in accordance with provided training and may not perform tasks for which they have not been adequately trained. Minimum training requirements include the following:

- **Initial Site Briefing:** All field personnel shall attend an initial site briefing conducted by the LMS project lead on the first day of work before conducting any fieldwork. The JSA and other field forms will be covered and signed at this time. If circumstances require the use of

personnel who did not attend the initial site briefing, these personnel will receive individual briefings from the LMS project lead before they may begin fieldwork.

- **Tailgate Safety Meetings:** At the beginning of each day's work and before specific tasks with significant or modified safety considerations, the LMS team will conduct an operations safety and health meeting for all personnel. The scope of the upcoming day's operations and activities will be reviewed, and hazards associated with those activities will be identified along with the safety implications and procedures to mitigate the hazards. Relevant safety documentation associated with the upcoming work will be reviewed. In addition, issues or concerns noted from the previous days' activities will be discussed. This briefing will be documented with a required sign-in sheet to identify the topics discussed and the personnel in attendance. A separate briefing with sign-in will be conducted for any worker(s) who requests to be on site and cannot attend the daily meeting. All workers are required to participate and sign-in or they will not be allowed on site.
- **Radiological Worker Level II (RWII) Training:** Workers performing or supporting excavation work within the radiological exclusion zone will have the potential to contact low-level radiological contamination. Radiological contamination may exist at the base of the radon barrier exposed during coring and excavation and while performing radon flux monitoring of the surface below. All work will be performed under supervision of a qualified radiological control technician. Radiological exclusion zone personnel shall be required to successfully complete RWII training provided by the LMS team and sign the radiological work permit. Workers who do not have the RWII certification will not be allowed to perform or support work within the radiological exclusion zones.

4.3 First Aid and CPR

The LMS team will provide a person who is trained in first aid and CPR to be onsite at all times while work is being performed. The LMS team will ensure that a first aid kit is onsite at all times when workers are present.

4.4 Personal Protective Equipment Within the Work Zone

The requirement for specific PPE, including when to wear it, will be determined in the JSA for the project by the LMS team. The LMS team reserves the right to adjust PPE requirements to protect personnel from hazards.

All personnel shall wear safety glasses with side shields or lens wraps and that are stamped on the frame as meeting ANSI/ISEA Z87.1, *American National Standard for Occupational and Educational Eye and Face Protection Devices*.

Hearing protection will be required whenever noise levels preclude holding a conversation by two people standing 3 feet apart or when safety personnel monitoring noise levels determine protection is required.

All workers shall wear shoes with safety toes (steel or composite), high-visibility safety vests, and hard hats when in the vicinity of the mini-excavator while it is in operation.

4.5 Sanitation

The LMS team will provide a chemical toilet and hand-washing station at the worksite.

4.6 Drinking Water

Bottled drinking water will be provided to the field crew by the LMS team, and proper hydration will be encouraged throughout the study.

4.7 Lightning

When an electrical storm is close enough to the worksite to be a hazard to site employees, personnel shall seek shelter in vehicles, equipment with cabs, low areas, or ground depressions and remain there until the contractor authorizes the resumption of work. Arroyos and other drainages are not suitable because of the potential for flash flooding.

The "flash-bang" method shall be used. The flash-bang method involves counting the time from seeing a flash of lightning to hearing the thunder. For each 5-second count, lightning is approximately 1 mile away. The flash-bang method will be used to determine if work will be halted. When the time interval is less than 30 seconds, indicating lightning within 6 miles, the site will be shut down and the situation reassessed every 30 minutes. Individuals may be instructed to sit in vehicles or drive to a lower point off the cover at the direction of the onsite Safety and Health representative.

4.8 Excavations

Excavations shall not exceed 4 feet in depth without proper consideration of soil types by a competent person in accordance with both Occupational Safety and Health Administration regulations and LMS requirements. Additional requirements (e.g., shoring, benching, and ingress/egress) will be necessary where excavations are expected to be (or become) more than 4 feet deep or other safety concerns exist. A task-specific JSA will authorize this work, outlining the specific requirements for various excavation depths. A work zone will be established and posted at each excavation location by the Safety and Health representative overseeing the study. These excavations may expose contaminated tailings or relocated contaminated materials, although they are expected to have limited radon exposure potential. RWII training discussed in Section 4.2 and dosimetry discussed in Section 4.12 will be requirements for access to the radiological work zone along with other directions and procedures dictated by the Safety and Health representative. Nonessential personnel for this subtask will remain outside the excavation work zone and will not require personal dosimetry or RWII training.

4.9 Safety Data Sheets

The research group shall submit to the LMS team a copy of the Safety Data Sheet (SDS) for each chemical the group intends to use on the jobsite. A copy of each SDS shall be kept on the jobsite and placed in a convenient location for all personnel to access.

4.10 Electrical Safety

All power tools shall be used with a ground-fault circuit interrupter device. No damaged cords, spliced cords, or tools with guards removed will be allowed on the LM site. Generators shall be grounded according to the manufacturer's instructions.

4.11 Radioactive Sources

Radioactive sources, including nuclear soil density gauges, shall not be brought on a jobsite without prior notification and approval from the LMS radiological control manager. Radioactive sources shall be identified by serial number and isotope and shall have passed a current integrity test. The source will be managed by the authorized individual and kept isolated from other site workers and dosimetry, then removed from the site each day.

4.12 Radiation Exposure Monitoring

In accordance with the *Radiation Protection Program Plan* (LMS/POL/S04373), Section 6.3, "External Dosimetry Program," the LMS team's objective is to keep individual radiation doses at ALARA levels and, in all cases, below the regulatory limits specified by 10 CFR 835. To accomplish this objective, LMS team management established administrative control levels in the LMS *Radiological Control Manual* (LMS/POL/S04322) that are below the regulatory limits to control individual and total radiation doses. The control levels are tiered, with increasing levels of authority required to exceed higher administrative control levels. Unless otherwise indicated, all administrative control levels and dose limits are stated in terms of the effective dose (millirem).

Given the nature of the work at LMS sites and the limited potential for personnel to exceed the radiation dose monitoring thresholds specified in 10 CFR 835 (i.e., 100 mrem whole body), personnel dosimetry is not currently used in support of the LM mission, in accordance with the *Radiation Protection Program Plan*, Appendix A. To ensure all operations remain conservative, the LMS *Radiological Control Manual* provides guidance for meeting the requirements of 10 CFR 835.

The LMS team's radiological operations will include real-time monitoring of all radiological work activities to include contamination control, dose determination, and decontamination, if needed.

5.0 Environmental Management System

In accordance with the LMS team's Environment, Safety, Health, and Quality Assurance policies and the Environmental Management System, all LMS personnel performing work for LM shall follow safe and environmentally sound work practices. Work shall be conducted in a manner that protects workers and the public, complies with DOE directives, and complies with applicable federal, state, and local requirements, agreements, and permits under the LM contract. In addition, work shall be conducted in a manner that prevents pollution, minimizes wastes, and conserves natural and cultural resources to the extent that such activities are technically and economically feasible. Additionally, the approach used for implementing the project and all

personnel will strive to minimize land disturbances caused at this site as a result of conducting this study.

Personnel are responsible for informing the project lead of any unsafe or environmentally unsound conditions and have the authority to stop work without fear of reprisal if necessary. A poststudy cover restoration report will be developed documenting site activities, restoration, and monitoring conducted to demonstrate that compliance and design requirements have been achieved.

5.1 National Environmental Policy Act

The portions of this Work Plan that will be conducted by NRC support justification for classification of this action as a Categorical Exclusion under NRC's 10 CFR 51.22(c)(6), which pertains to confirmatory research that does not involve any significant construction impacts. The portions of this Work Plan that will be conducted by DOE were assessed in a NEPA Categorical Exclusion evaluation (LM 22-17). It was determined that these actions do not individually or cumulatively have a significant effect on the human environment, thereby supporting justification for classification of this action as a Categorical Exclusion under DOE NEPA regulations in 10 CFR 1021.410. Proposed activities fit within the following categories: B3.1, Site characterization and environmental monitoring, and B3.8, Outdoor terrestrial ecological and environmental research. Because Categorical Exclusions apply to the actions proposed in this Work Plan, the Lakeview study does not require an Environmental Assessment or an Environmental Impact Statement.

5.2 Cultural Resources

LM completed an archaeological reconnaissance (Phase III) survey of the proposed off-cover, analog location. An archaeological survey was not required for the cover test pit locations because they are already disturbed to a depth greater than what is proposed for this soil study. No archaeological resources were found at the surveyed locations that warranted additional work. LM made a finding of "no historic properties affected" and has communicated this finding in writing to the Oregon State Historic Preservation Officer and the local tribes; the study at the analog location may proceed if they concur with this finding or no response is received within 30 days. Work within the previously disturbed disposal area can proceed with no further review for cultural resources.

If any suspected cultural materials are discovered during construction, work in the area shall halt immediately, LMS Environmental Compliance (EC) and DOE must be contacted, and the materials must be evaluated by an archaeologist or historian meeting the Secretary of the Interior's Professional Qualification Standards (Volume 48 *Federal Register*, page 22716).

The majority of the work will take place on the engineered cover of the disposal site. The cover is a modern engineered feature that has no cultural resources sensitivity. Radon barrier restoration soils will be replaced with what was excavated and stock piled and supplemented with minor volume (less than 2 cubic feet) obtained from the analog test pit location next to the disposal cell and adjacent to the former borrow area at the time of construction.

5.3 Migratory Bird Treaty Act

The Migratory Bird Treaty Act prohibits harassing or otherwise disturbing nesting birds; removing nests, eggs or young birds; or "taking" a migratory bird in any way. All listed birds and their occupied nests are protected year-round by the Act. Birds of Conservation Concern (BCCs) are migratory birds with special protection. BCCs that may be present at the Lakeview site year-round include the bald eagle (*Haliaeetus leucocephalus*), Cassin's finch (*Haemorhous cassinii*), ferruginous hawk (*Buteo regalis*), greater sage-grouse (*Centrocercus urophasianus*), Lewis's woodpecker (*Melanerpes lewis*), loggerhead shrike (*Lanius ludovicianus*), short-eared owl (*Asio flammeus*), and white-headed woodpecker (*Picoides albolarvatus*). If BCCs are tentatively identified at the site, personnel shall not work in or travel in areas outside of the approved work areas or access routes without approval. Personnel shall not harass or otherwise disturb or move active bird nests, eggs, or young birds. If an active nest or eggs are discovered in the work area, personnel shall notify EC and resolve any Migratory Bird Treaty Act concerns before work can continue.

5.4 Endangered Species Act and State Endangered Species

No threatened or endangered species are known to exist at the site because no habitat for these species exists on or near the site. The site is also not within designated critical habitat for any threatened or endangered species. The majority of the work will take place on the engineered cover of the disposal site. The cover is a modern engineered feature that is predominantly vegetated by seeded reclamation grasses and volunteer shrubs. Some investigations into the soil profile will also take place on areas of the site that are within arid sagebrush shrublands and have undisturbed soils. No endangered species are likely to exist in these areas. The site is within the range of one State-listed threatened species, the kit fox. Although the species is unlikely to occur at the site, no excavations can occur in the vicinity of kit fox dens. No habitat exists at the site for any other State-listed species.

5.5 Waste Management

Personnel shall properly manage all waste generated by project activities. No hazardous or radioactive waste materials are expected to be generated during field activities. The site shall be kept clean and orderly. Personnel shall clean up debris and waste material from the site daily. Construction debris and nonhazardous waste material are expected to be very minimal and shall be disposed of in approved receptacles daily in town. Although not anticipated, personnel shall immediately notify the project lead if any hazardous waste is suspected or generated outside the scope of the project and follow the EC's directions to manage the waste. The LMS project lead will be ultimately responsible to ensure all adhere to these waste management requirements.

Additionally, PPE and investigation derived waste generated at the radon barrier interface with the mill tailings waste shall be radiologically scanned to determine if it can be released for management as a solid waste. Although it is not anticipated that radiologically contaminated PPE will be generated as a result of this study, if it is generated, it can be disposed at the Grand Junction, Colorado, UMTRCA Title I Disposal Site

5.5.1 Waste Reduction and Recycling

Work will be performed in an environmentally responsible manner consistent with the LMS *Environmental Management System Sustainability Teams Manual* (LMS/POL/S11374) waste reduction and recycling targets. In working toward these targets:

- All personnel are encouraged to minimize the waste generated and maximize the amount of material that is reused, salvaged, and recycled.
- All materials recycled and disposed of shall be tracked with total volumes or weights by the project lead, who will report the totals to EC.

5.6 Spills

If spills of any fluids from equipment operations or maintenance (e.g., fuel, hydraulic fluids, coolant, lubricants, cleaning solvents, used oil) occur, personnel shall immediately notify the project lead, Safety and Health, and EC and follow their directions to clean up the spill. All spills will be managed in accordance with the *Environmental Instructions Manual* (LMS/POL/S04338). Equipment leaks and other types of spills shall be diapered, contained, absorbed, or otherwise blocked to prevent ground surface contamination until the leak is repaired or the equipment is replaced. Personnel shall clean up and subsequently manage spilled materials and associated wastes (e.g., contaminated soils), including proper storage, until EC can arrange for offsite disposal of the material.

5.7 Driving on the Disposal Cell Cover

Driving on the disposal cell cover is a necessary aspect of the study. Precautions will be taken to reduce the impact to the disposal cell cover. Vehicular traffic will be minimized at all times and will not be allowed if muddy conditions are present. Vehicles are to take different paths to avoid creating ruts or paths on the vegetated cover or take established paths directly upslope or downslope on armored riprap covers. Vehicles that will be used on the cover consist of a tracked mini-excavator and utility task vehicles (UTV). The mini-excavator will be required to travel to each test pit location. A progressive approach will be taken in moving from one test pit to another to avoid back-and-forth travel between test pits as much as possible. A vehicle and equipment staging area will be set up off the disposal cell along the main entrance road.

6.0 References

10 CFR 835. "Occupational Radiation Protection Program," *Code of Federal Regulations.*

10 CFR 51.22. "Criterion for categorical exclusion; identification of licensing and regulatory actions eligible for categorical exclusion or otherwise not requiring environmental review," *Code of Federal Regulations.*

10 CFR 1021 "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations.*

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Appendix A

Sections from the *Long-Term Cover Performance Projects* Technical Task Plan

Section 1: Introduction and Objectives
Section 2: Relevance
Section 3: Background
Section 4: Project 1: Effects of Soil-Forming Processes on Cover Engineering Properties

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LMS/S12624

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Technical Task Plan
U.S. Department of Energy
Office of Legacy Management
AS&T Subtask Order
TTP No.: 003—Version 0.0
Title: Long-Term Cover Performance Projects

February 2015

Draft - Pre-decisional Document

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AS&T Subtask
Technical Task Plan: Long-Term Cover Performance Projects

Revision Number	Revision Date	Description of Change
0.0	February 2015	Initial issue.

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Contents

Figures

Tables

Abbreviations

AS&T	Applied Studies and Technology
ASTM	American Society for Testing and Materials International Standard
CFR	*Code of Federal Regulations*
cm	centimeter
DOE	U.S. Department of Energy
E-PERM	electric passive radon monitor
ECAP	Enhanced Cover Assessment Project
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
FY	fiscal year
GJDS	Grand Junction Disposal Site
ha	hectare
HDPE	high-density polyethylene
HH&E	human health and the environment
LAI	leaf area index
LM	Office of Legacy Management
LTCP	Long-Term Cover Performance
LTS&M	long-term surveillance and maintenance
LTSP	long-term surveillance plan
m	meter
mm	millimeter
MPa	megapascal
MTLs	Maximum Tolerable Limits or maximum tolerance levels
NRC	U.S. Nuclear Regulatory Commission
pCi	picocuries
SDRIs	sealed-double ring infiltrometers
SN3	Stoller Newport News Nuclear, Inc., a wholly owned subsidiary of Huntington Ingalls Industries, Inc.
SWCC	soil water characteristic curve(s)
TDR	time-domain reflectometry
TTP	Technical Task Plan
UMTRCA	Uranium Mill Tailings Radiation Control Act

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Executive Summary

The U.S. Department of Energy Office of Legacy Management (LM) is responsible for long-term surveillance and maintenance (LTS&M) of disposal cells for uranium mill tailings throughout the United States. The long-term protectiveness of disposal cells relies on engineered covers to limit radon releases, rainwater percolation, and erosion. Natural ecological and soil-forming processes are slowly changing the as-built engineering properties of disposal cell covers in ways that may alter protectiveness and increase LTS&M costs. This Technical Task Plan describes four ongoing Applied Studies and Technologies Surface Projects designed to evaluate effects of natural processes on the performance of disposal cell covers, investigate options for improving LTS&M of covers, and thereby inform LM managers as they fulfill their responsibilities to comply with applicable laws and regulations, maintain long-term protectiveness, and reduce long-term costs. For all projects we establish collaboration and cost sharing with other researchers and agencies, foster education with a focus on stakeholder communities, and disseminate new knowledge through presentations and peer-reviewed publications.

Effects of Soil-Forming Processes on Cover Engineering Properties. This project will (1) characterize the morphology of disposal cell cover soils to understand the natural processes that are changing engineering properties and the degree of change over decades and millennia, (2) measure effects of soil-forming processes on gas diffusivity and soil hydraulic properties, (3) determine how changes in engineering properties vary with depth in cover profiles, and (4) measure and model how these changes influence radon flux rates and rainwater percolation. Four sites that represent a range of cover types, climates, site conditions, and vulnerabilities to change will be selected for study. We will characterize soil morphology in test pits on covers and at natural analog sites to understand near-term and potential long-term pedogenesis. In the cover test pits we will evaluate methods and scales for measuring radon flux, physical properties that influence radon flux, and depth-dependent soil hydraulic properties. Changes in physical and hydraulic properties since construction, and changes in radon flux and percolation rates in response to natural soil formation, will then be calculated and modeled. The project is scheduled to be completed in 2018.

Contaminant Uptake by Plants on Disposal Cells. LM managers need to understand the complex tradeoffs of potential detrimental and beneficial effects of plants growing on disposal cell covers to be able to develop a rational and consistent vegetation management policy. We designed this project to determine if plants growing on disposal cells create exposure pathways by taking up and disseminating tailings constituents through animal foraging on stems and leaves. The study focused on sites near Native American communities in western states that represent a range of climates, cover designs, cover soil types, and vegetation types. For each site we (1) sampled leaves and stems of plants currently rooted in covers with plants growing in off-cell reference areas, (2) compared levels of tailings elements in plant tissues on and off the cell, and (3) compared plant levels to dietary tolerance levels set for livestock and, in so doing, assessed animal foraging as a potential exposure pathway. In 2015 we plan to determine the potential for long-term bioaccumulation of tailings constituents in plant litter and soil organic matter, and then draft a paper for publication.

Water Balance Cover Monitoring. This project is the culmination of a multiyear effort to develop, test, construct, and monitor a sustainable alternative to covers containing compacted soil barriers, focusing on controlling percolation. Conventional covers rely on compacted soil to function as a low-flow barrier to percolation. Water balance covers mimic natural soil water cycling in arid and semiarid areas; precipitation is stored in a soil sponge and then released back into the atmosphere through soil evaporation and plant transpiration. The alternative design was tested on a small scale over many years by LM and other agencies. For this project we embedded instrumentation during construction of a water balance cover on the Monticello disposal cell to monitor on a very large scale. We also characterized changes in soil engineering properties several years later. We plan to continue monitoring percolation through the cover and other soil hydrology parameters long enough to capture responses to soil formation, ecological succession, and climate variability. By doing so we're providing LM and other agencies, nationally and internationally, with unprecedented, large-scale, long-term performance monitoring of an in-service water balance cover.

Enhanced Cover Assessment Project. Multiple lines of evidence show that natural ecological and soil-forming processes are changing engineering design properties of covers. Studies by U.S. Environmental Protection Agency and others show that these changes can increase percolation. LM managers may need to know if similar changes could occur at their sites, and if so, to be prepared for corrective actions if warranted. For this project we developed a method and to monitor directly (not calculate) percolation through disposal cell covers. We are also testing methods to enhance cover performance and reduce cost in the long term. We designed and constructed two test facilities: a large test pad and lysimeter test sections. We are using the test pad to demonstrate and evaluate soil manipulation and revegetation methods with the goal of exploiting natural processes in ways that transform conventional covers into water balance covers. We are using the lysimeter test sections to evaluate natural changes in the soil engineering properties of a conventional cover, and then to monitor percolation (and other water balance parameters) over several years, comparing the hydraulic performance of an as-built conventional cover with the same cover that has been transformed (enhanced) to function as a water balance cover.

1.0 Introduction and Objectives

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for post-closure stewardship of disposal cells constructed throughout the United States as required by the Uranium Mill Tailings Radiation Control Act (UMTRCA). We inspect and maintain disposal cells (Long-Term Surveillance and Maintenance—LTS&M) to ensure protection of human health and the environment (LM Goal 1). We recognize that disposal cell protectiveness may change over time, so we made commitments to understand and respond to these changes: to "record and analyze data on long-term performance," "study and apply new technologies that enhance protectiveness and are cost effective," and "take any corrective actions necessary to modify engineered cells" (DOE 2011). Fulfilling these commitments will enable LM to satisfy Goal 1 objectives: (1) comply with environmental laws and regulations, (2) reduce health risks and LTS&M costs, and (3) improve the long-term sustainability of environmental remedies (DOE 2011).

UMTRCA disposal cells are covered with engineered earthen layers designed to contain tailings contaminants for the long term. Natural ecological and soil-forming processes are slowly changing the as-built engineering properties of disposal cell covers in ways that may increase LTS&M costs and reduce long-term protectiveness. On the other hand, natural processes are also transforming how covers function in ways that LM could exploit to enhance protectiveness and reduce LTS&M costs. LM will use results of the projects described in this Technical Task Plan (TTP) to weigh the complex balance of potential detrimental and beneficial effects of inevitable natural changes in disposal cell covers.

This TTP describes a suite of interrelated projects designed to produce the data LM managers need to make informed decisions about LTS&M of UTMRCA disposal cell covers. The projects are evaluating effects of natural processes on cover performance and new technologies that may enhance protectiveness and reduce costs in the long term. Results will help managers answer the following types of questions regarding LTS&M of covers:

- Under what conditions should vegetation be allowed to grow on disposal cells?
- Have changes in site conditions increased radon flux and soil water percolation? If so, what are the regulatory risks, and are covers *currently* protective of human health and the environment?
- Could site conditions that would increase radon flux, soil water percolation, or erosion change over the design life of a cover —will covers be protective in the *long term*?
- Are disposal cell covers at Title II transition sites acceptable as designed or as built, or will they require modification before or after transfer to LM?
- How would water percolation and radon flux through in-service covers be monitored if regulatory requirements change, placing greater emphasis on performance monitoring?
- What technologies could be used to modify a cover if a corrective action is necessary?

Table 1 outlines objectives of existing Long-Term Cover Performance (LTCP) projects. Section 2.0 identifies elements of the LM Strategic Plan (DOE 2011) that warrant these projects and outlines how the projects could improve LTS&M of disposal cell covers. Section 3.0 summarizes the technical literature that embodies our current understanding of how natural

processes are changing the as-built properties and performance of covers. Sections 4.0–7.0 present study questions, data needs, field methods, data analysis methods, and work completed to date for each project. Section 8.0 shows schedules and milestones for all projects.

Table 1. Objectives of LTCP Projects

Project Title	Objectives
1. Effects of Soil-Forming Processes on Cover Engineering Properties	1. Identify and quantify rates of soil-forming processes that may change as-built engineering properties of UMTRCA covers in the short term and in response to climate change in the long term. 2. Determine how soil formation varies with depth for a range of cover thicknesses, soil types, and climates. 3. Evaluate effects of soil formation on the hydraulic conductivity and gas diffusivity of low-permeability radon barriers. 4. Measure how soil formation influences surface flux of radon and percolation of meteoric water in UMTRCA covers.
2. Contaminant Uptake by Plants on Disposal Cells	1. Compare levels of tailings constituents in plants currently rooted in covers with plants growing in reference (control) areas. 2. Evaluate several UMTRCA sites that represent a broad range of climates, cover designs, cover soil types, and vegetation types. 3. Assess an animal-foraging pathway for contaminant transport by comparing plant levels to dietary tolerance levels set for livestock. 4. Gauge on the basis of existing literature the potential for long-term bioaccumulation of tailings constituents in plant litter and soil organic matter.
3. Water Balance Cover Monitoring	1. Demonstrate methods for large-scale monitoring (lysimetry) of an in-service water balance (evapotranspiration or ET) cover. 2. Characterize changes in soil engineering properties of a water balance cover. 3. Monitor the water balance response, including percolation, to soil formation, ecological succession, and climatic variability. 4. Transfer LM's water balance cover technology to other agencies, nationally and internationally.
4. Enhanced Cover Assessment Project	1. Directly monitor the soil water balance, including percolation, of a conventional UMTRCA cover. 2. Evaluate short-term (5-year) changes in the soil engineering properties of a conventional UMTRCA cover. 3. Demonstrate and evaluate soil manipulation and revegetation methods designed to transform an UMTRCA cover into a water balance cover. 4. Monitor and compare the water balance (including percolation) of a conventional UMTRCA cover and an enhanced (transformed) cover for 10 or more years.

2.0 Relevance

The LM Strategic Plan (DOE 2011) outlines objectives and strategies that LM will follow to continually improve LTS&M and ensure future protection of human health and the environment (HH&E). Current LTCP projects are the products of analysis of how the Strategic Plan applies to LTS&M of UMTRCA disposal cells (Table 2). This analysis identified several opportunities for improving LTS&M of disposal cell covers (Table 3). LTCP projects address gaps in our understanding of how covers are changing, whether changes are influencing protectiveness, and if we can implement improvements that will have the potential to reduce regulatory and HH&E risks, and LTS&M costs.

Table 2. Relevance of LTCP Projects (see DOE 2011)

<table>
<tr><th>Objective 1: Comply with environmental laws and regulations.</th></tr>
<tr><td>Strategy: Prepare, update, and implement LTS&M plans that protect human health and the environment.
LTS&M of disposal cell covers varies widely. For example, Long-Term Surveillance Plans (LTSPs) require removal of vegetation at some sites, whereas at other sites, plants are allowed to grow. LTCP projects will lead to consistent, science-based vegetation management.
The current LTS&M practice of monitoring groundwater as a measure of cover performance does not provide an early warning of changes in engineering properties brought about by natural processes. LTCP projects will provide LM with options for direct monitoring and modeling of leading indicators of changes in cover performance.</td></tr>
<tr><td>Strategy: Work closely with federal, state, local, and tribal governments to set clear expectations.
Applied Studies and Technology (AS&T) scientists have a long history of working with federal and tribal governments through research collaboration and participation in workshops and expert panels. LTCP projects are continuing these interactions to advance the science and also to promote common expectations.
AS&T scientists will continue sharing technical information at workshops and quarterly meetings with state, local, and tribal representatives. Open communication may foster an understanding that levels of monitoring and maintenance should match risk levels and performance requirements.</td></tr>
<tr><td>Strategy: Monitor, and prepare to act on, proposed changes to environmental laws and regulations.
U.S. Environmental Protection Agency (EPA) and U.S. Nuclear Regulatory Commission (NRC) are reviewing potential revisions for LTS&M of UMTRCA sites under 40 Code of Federal Regulations (CFR) Part 192, to make requirements more risk informed and performance based rather than prescriptive and design based, and to place greater emphasis on performance monitoring strategies. LTCP projects will prepare LM to act on proposed changes if warranted.</td></tr>
<tr><th>Objective 2: Reduce health risks and LTS&M costs.</th></tr>
<tr><td>Strategy: Evaluate the range of risks and address the highest ones first.
LTCP projects are generating data that LM can use to prioritize sites using broad risk criteria and cost-benefit evaluations of potential LTS&M improvements.
Applications of LTCP projects will be based on a systematic screening and ranking of sites to determine the best candidates for improvements.</td></tr>
<tr><td>Strategy: Negotiate changes to LTS&M plans that maintain compliance objectives and reduce cost.
In the past, LM successfully negotiated with NRC for cost-reducing changes in LTSPs based on results of LTCP projects. Results of current projects could produce similar outcomes.</td></tr>
<tr><th>Objective 3: Improve the long-term sustainability of environmental remedies.</th></tr>
<tr><td>Strategy: Record and analyze data on long-term performance of disposal cells, groundwater treatment systems, and institutional controls.
Long-term performance projects are generating and analyzing data on how natural processes are changing cover engineering properties and how cover protectiveness can be sustainably enhanced.
Twenty years ago, AS&T scientists collaborated with DOE Office of Environmental Management (EM) and EPA to identify and evaluate scenarios for long-term changes in cover protectiveness. LTCP projects are refining an approach that combines current monitoring; clues from natural analogs; climate modeling; and ecohydrology, radon, and erosion modeling.</td></tr>
<tr><td>Strategy: Collaborate with, and offer “test beds” to organizations that fund LTS&M research and development.
AS&T scientists have a long history of using UMTRCA sites as “test beds” in collaboration with organizations that fund cover research, such as EM, DOE Office of Science, EPA, NRC, national laboratories, and research universities. Current LTCP projects are continuing this practice of collaboration and cost sharing.</td></tr>
</table>

Table 3. Opportunities for Improving LTS&M of Disposal Cell Covers that Will Rely on the Outcomes of LTCP Projects

1. Site-Specific Vegetation Management

Current Situation:

Plants can have both detrimental and beneficial effects on the long-term performance of disposal cell covers due to coupled plant-soil interactions and soil-forming processes (Section 3.0). Effective vegetation management will require an understanding of the complexities and tradeoffs. Indeed, how well we understand and manage plant ecology in the short term may influence how well a cover performs in the long term. However, vegetation management plans for UMTRCA disposal cell covers currently vary widely from site to site. Control of all vegetation is required at some sites, whereas deep-rooted plants are allowed to grow on covers at other sites.

Potential Improvement:

Tailor vegetation management plans to reflect site conditions. Site-specific plans would be based on applicable regulations and guidance, an assessment of risks to HH&E at sites where vegetation is potentially contributing to contaminant transport, our understanding of the roles plants play in enhancing the performance of certain types of covers, and the cost of vegetation management.

2. Direct Cover Performance Monitoring

Current Situation:

Current LTS&M guidance includes hydraulically down-gradient groundwater monitoring and downwind radon monitoring as near-term, indirect measures of cover performance. However, this retrospective (after-the-fact) monitoring approach does not provide an early warning if natural processes acting on earthen cover layers were to cause unacceptable increases in radon flux or water percolation. NRC is considering revising LTS&M guidance to be more risk-informed and performance-based, placing greater emphasis on direct monitoring and modeling strategies (NRC 2011).

Potential Improvement:

Prepare to act on potential changes in regulatory guidance (Table 2) by (1) improving understanding of key natural processes and cover system behavior, (2) developing a risk-based approach for screening and prioritizing sites to determine which ones may require monitoring, and (3) producing protocols for monitoring and modeling leading indicators of radon flux and water percolation.

3. Evaluation of Cover Enhancements

Current Situation:

The Strategic Plan assures the public that LM will "study and apply new technologies that enhance protectiveness and are cost effective" and "take any corrective actions necessary to modify engineered cells." LM may need to evaluate technologies that enhance or modify engineered disposal cell covers, thereby fulfilling these commitments.

Potential Improvement:

Expand the scope of ongoing cover enhancement studies to include effects of enhancement methods on radon attenuation, biological intrusion, bio-uptake of tailings contaminants, and cover erosion, and then screen sites to determine, on the basis of regulatory and HH&E risks, which ones might be future candidates for enhancement or modification.

4. Long-Term Performance Projections

Current Situation:

The longevity requirement for UMTRCA disposal cells was set at 1,000 years, as possible, with a minimum requirement of 200 years. Similarly, Executive and DOE Orders obligate LM to evaluate adaptation of disposal cells and other remedies to climate change. Evidence published by DOE, EPA, and others suggest that natural ecological and soil-forming processes begin changing the engineering properties of existing covers within 5 to 10 years (Section 3.0).

Potential Improvement:

Develop a defensible framework for projecting the long-term performance of disposal cell covers that takes into account likely changes in ecology, soil engineering properties, and climate over the mandated design life of disposal cell covers.

3.0 Background: Natural Changes in the Engineering Properties of Disposal Cell Covers

Natural soil-forming and ecological processes can change the engineering properties of earthen covers on uranium mill tailings disposal cells. LTCP projects are evaluating possible detrimental and beneficial effects of these changes and options for improving LTS&M of disposal cell covers (DOE 2013a, 2014).

UMTRCA authorized the long-term containment of tailings contaminants in engineered disposal cells. The engineered covers on UMTRCA disposal cells (Figure 1) include an earthen barrier layer comprised of compacted fine-textured soil designed to limit the surface flux of radon to less than 20 picocuries (pCi) m^{-2} s^{-1} (NRC 1989), and to control percolation of meteoric water into the tailings (DOE 1989). For some engineered covers, this "low-permeability radon barrier" is overlain by a compacted earthen "protection layer" designed to prevent damage from freeze-thaw and wet-dry cycles (DOE 1989). Most covers are also armored at the surface with a durable rock "riprap layer" designed to withstand water and wind erosion events (NRC 2002). The riprap layer is most often placed on a "bedding layer" that also serves to shed rainwater. Earthen covers were designed to control radon flux, protect groundwater, and withstand erosion "for a period of 1,000 years to the extent reasonably achievable" (40 CFR 192).

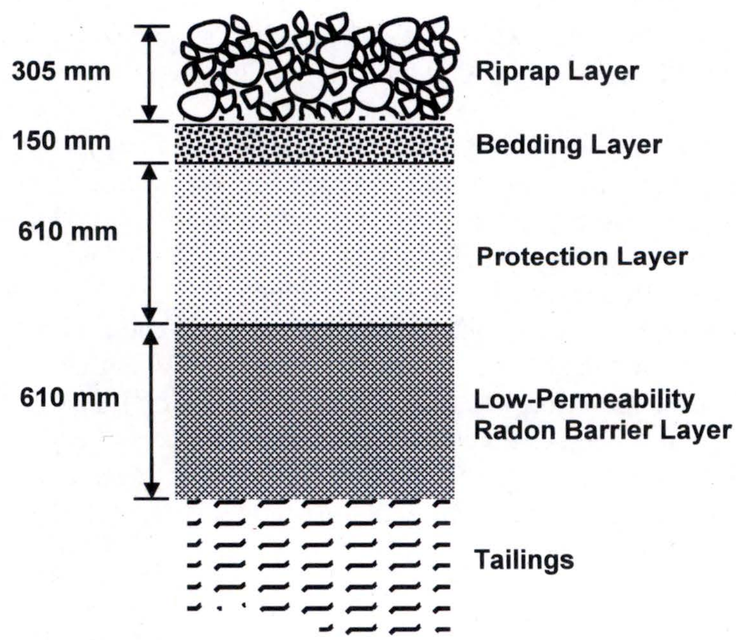

Figure 1. Example of an UMTRCA Disposal Cell Cover

The as-built engineering properties of earthen covers are subject to change by natural ecological and soil-forming processes over relatively short time periods regardless of climate or the type of cover design (Benson et al. 2007, 2008; DOE 1999; Waugh et al. 2007; NRC 2011). Designers of UMTRCA covers expected the rock riprap layers, designed for erosion control, to also prevent plant germination and establishment (DOE 1989). To the contrary, rock-armored surfaces have

been found to create favorable habitat for deep-rooted plants, in all climates, by reducing soil evaporation, increasing soil water storage, and trapping windblown dust, thereby providing water and nutrients for plant germination and establishment (Groenevelt et al. 1989; Waugh et al. 1994; Kemper et al. 1994; Sackshewsky et al. 1995). Tap roots often extend vertically through riprap and bedding layers and then branch and spread laterally at the interface with underlying protection or barrier layers. Secondary and tertiary roots often extend vertically into and through protection and barrier layers where they become fibrous root mats following soil structural planes (Albright et al. 2006b, Benson et al. 2008, Waugh et al. 2007; DOE 1992, 1999).

Within 5 to 10 years, natural soil-forming processes create structure with larger pores in compacted fine-textured soil layers, increasing porosity and saturated hydraulic conductivity, and reducing the air entry pressure, sometimes by several orders of magnitude (Benson et al. 2007, Waugh et al. 2007; DOE 1999; Albright et al. 2006a, b; NRC 2011). Percolation and radon fluxes may increase as a result of these changes (Lewis and MacDonell 1990; Morris and Fraley 1989; Albright et al. 2006a, 2006b, 2010). Processes that initiate these changes include freeze–thaw and desiccation cracking (Kim and Daniel 1992; Benson et al. 1993; Albrecht and Benson 2001), retention of borrow soil structure during construction (NRC 2011; Albright et al. 2006a), and biointrusion (Hakonson 1986; Suter et al. 1993; Bowerman and Redente 1998; NRC 2011). Greater changes in hydraulic properties occur in less permeable, highly compacted clayey soil layers; smaller changes occur in soils that are less compacted and more permeable when placed (Benson et al. 2007; NRC 2011). Over time, the hydraulic properties of cover soils become similar to the original undisturbed borrow soil properties regardless of the as-built condition (NRC 2011), potentially resulting in greater soil water storage, soil evaporation, plant growth, and plant transpiration.

These natural changes in engineered soil properties may also introduce an alternative means for controlling percolation in the long term. In arid and semiarid ecosystems, relatively low precipitation, high potential evapotranspiration (ET), and thick unsaturated soils often limit percolation and recharge (Gee and Tyler, 1994). Disposal cell covers designed to mimic this natural soil water balance, often referred to as water balance covers or ET covers (Albright et al. 2010), can provide hydraulic isolation in semiarid and arid regions (Albright et al. 2004; Anderson et al. 1993; Ward and Gee 1997; Waugh et al. 2009; Scanlon et al. 2005; Benson and Bareither 2012; Apiwantragoon et al. 2014). Therefore, natural soil-forming and ecological processes that slowly transform engineered earthen covers with compacted fine-textured layers into vegetated soil profiles resembling water balance covers may provide long-term advantages compared with the original compacted soil designs (DOE 2013b, 2014).

4.0 Project 1: Effects of Soil-Forming Processes on Cover Engineering Properties

4.1 Overview and Objectives

We designed this project to improve our understanding of the effects of natural soil-forming processes on the engineering properties within profiles of earthen disposal cell covers for uranium mill tailings. Project results will support the efforts of LM site managers to evaluate the regulatory and HH&E risks of changes in cover engineering properties, and, if warranted, to prioritize sites for LTS&M improvements (Section 2.0).

Previous research at disposal facilities has demonstrated how soil-forming and ecological processes have created cracks in the structure of compacted soil layers, such as low-permeability radon barriers, thereby increasing hydraulic conductivity and potentially increasing gas diffusion (Section 3.0). Changes in soil hydraulic properties have been well-documented in the upper meter of cover profiles. However, there is a poor understanding of (1) relationships between changes in soil morphology and as-designed soil engineering properties in UMTRCA covers, (2) depths at which soil-forming processes will change engineering properties for a range of site conditions (climate, soil type, ecology), (3) how and at what rate plant-soil-microbial feedbacks evolve in cover systems and implications for as-designed engineering properties and (4) long-term effects of soil formation with respect to percolation and radon flux rates.

We distilled four objectives for this project:

- Identify and quantify rates of soil-forming processes that may change as-designed engineering properties of UMTRCA covers in the short term and in response to climate change in the long term.
- Determine how soil formation varies with depth for a range of cover thicknesses, soil types, climates, and ecological conditions.
- Evaluate effects of soil formation on the hydraulic conductivity and gas diffusivity of low-permeability radon barriers.
- Evaluate effects of soil-forming and ecological processes on surface flux of radon and percolation of meteoric water in UMTRCA covers.

4.2 Data Needs, Methods, and Analyses

Data needs and analytical tools may be modified during the course of the study. We plan to periodically revisit data deficiencies, field methods, and data analysis methods after field work gets underway. The initial data needs fall into four categories: test site selection, soil morphology, radon flux measurements, and depth dependent soil hydraulic properties. Table 4 is a summary of study questions, data needs, variables, and data analysis approaches.

Table 4. Summary of Study Questions and Related Data Needs, Variables, and Data Analysis for the LTCP Project: Effects of Soil-Forming Processes on Cover Engineering Properties

Study Question	Data Needs	Data Interpretation/Analysis	
		Variables	**Data Analysis**
Which four UMTRCA covers rank highest as test sites on the basis of vulnerability to natural processes?	Existing data on Title I and II site conditions	• Tailings radiological variables • Cover design and as-built engineering properties • Vegetation type and maturity • Quality and accessibility of natural analog sites	Tabulate, screen, score, rank, and select four sites.
What diagnostic soil morphological changes have occurred in the short term, may occur in the long term, and at what depths?	Morphology of soil profiles and plant communities in and on disposal cell covers and at natural analogs sites	• Soil macromorphology variables (Soil Survey Staff 1975, 2003) • Soil micromorphology variables • Soil edaphic properties (physical, chemical, microbiology, fertility) • Digital soil morphometrics (x-ray diffraction, near infrared, electrical conductivity) • Plant species composition and abundance (percent cover, density, and leaf area index)	• Use diagnostic soil morphology properties in covers and natural analogs, and the extensive body of literature on changes in natural and manmade soils, to interpret cover profile technogenesis. • Statistically compare plant species and abundance for covers and natural analogs.
Have soil-forming processes changed cover engineering properties and radon flux rates?	Large-scale field measurements and modeling of radon flux in test covers	• Radon flux using 1.5 meter (m) × 1.5 m sealed-double ring infiltrometers chambers • Radon flux using 0.3 m diameter chambers • Radon measured with activated carbon sorbent • Radon measured using electric passive radon monitor detectors • Volumetric water content and dry unit weight of radon barrier • Lead-210 sorbed on radon barrier by gamma emission and inductively coupled plasma mass spectrometry • Soil water potential using chilled hygrometer	• Statistically compare current measured radon fluxes with as-built and modeled radon fluxes. • Statistically compare large- and small-scale radon fluxes to test for scale effects. • Adjust comparisons for differences in soil water content, dry weight density, and source concentrations.
Have soil-forming processes changed soil hydraulic properties and at what depths?	Profiles of soil hydraulic properties in test covers	• Vertical profiles (stacked) of large (450 millimeter diameter) soil blocks • Hydraulic conductivity using flexible-wall permeameters and large-scale pressure plates • Soil water characteristic curve using pressure plate extractor and chilled mirror hygrometer	• Statistically compare current and as-built hydraulic properties. • Estimate percolation rates using WinUNSAT-H, inputting site soil hydraulic properties and climate data. • Compared modeled percolation rates for as-built and current soil hydraulic properties.

4.2.1 Test Site Selection

Funding will limit the study to four UMTRCA sites. A range of sites will be selected with the goal of wide applicability (generalizability). Four study sites will be selected to represent a range of site conditions: climates, cover profile thicknesses, ecological stages, soil types, and radium concentrations in tailings. Selection will be biased to favor sites thought to be most vulnerable to

changes in soil engineering properties that could lead to increases in percolation and radon flux rates. For example, a dry site with a relatively thin cover profile, mature woody vegetation, a highly compacted clay radon barrier, and tailings with relatively high radium levels may be most vulnerable to an increase in radon flux. Existing data on site conditions will need to be compiled as a basis for scoring, ranking, and selecting the four study sites.

4.2.2 Soil Morphology

Soil formation (pedogenesis) is inevitable and ubiquitous in all natural landscapes. Soil scientists recognize five major factors that influence soil formation: parent material, climate, living organisms, topography, and time. The combined influence of these soil-forming factors determines the biotic and abiotic properties of a soil and their degree of expression. The morphology of a soil is the collection of observable characteristics (properties) that reflect both in situ conditions and local soil-forming processes. Soil scientists use morphological characteristics such as structure (aggregation of particles and formation of cracks between aggregates), texture (proportions of sand, silt, and clay), and diagnostic horizons (properties of soil profile layers that provide evidence of specific pedogenic processes) to classify soils (Soil Survey Staff 1975, 2003).

Given the significant physical alterations needed to accommodate engineering design goals, UMTRCA cover systems represent novel soil systems and are classified by soil scientists as Technosols (soils of human construction). In the effort to determine rates of soil change with implications for as-designed engineering conditions, we will characterize and classify the morphology of engineered cover profiles and natural analog soil profiles to understand (1) the processes that are changing soil engineering properties, and (2) the degree of change that occurs in both the near term (decades) and long term (millennia). Natural analogs are sites with undisturbed soil types similar the cover soils and late-successional vegetation (ideally an undisturbed area at the soil borrow site for the radon barrier).

Soil morphology will be characterized in test pits excavated on disposal cell covers and at natural analog sites using standard soil survey methods, soil micromorphology, and digital soil morphometrics (electrical conductivity, x-ray fluorescence, and near-infrared mapping of soil profiles). Given the novel technogenic nature of UMTRCA cover systems, the systematic identification and morphological characterization of natural analog sites will allow the extensive body of literature on soil change in natural soil systems to be integrated with confidence.

4.2.3 Radon Flux Measurements

Representative radon flux measurements will be needed at selected sites to compare with the regulatory radon flux standard (20 pCi m^{-2} s^{-1}) and with as-built radon flux measurements. We plan to measure radon fluxes at 6-10 locations at each of the four sites using both large-scale and conventional-scale (Burnett et al. 1995) flux chambers. The large-scale chambers (1.5 meter (m) × 1.5 m square) are adapted from the inner "ring" of sealed-double ring infiltrometers (SDRIs) that we used previously to capture effects of pedogenic processes on soil hydraulic properties (Benson et al. 2006, 2008, 2011). The large scale is necessary to ensure that radon flux measurements are made over an area sufficiently large to encompass radon movement through macropore structure in the radon barrier. Large-scale chambers will be sealed to the surface of radon barriers after overlying riprap and bedding layer materials have been moved

(Figure 2). We will place three conventional-scale flux chambers (0.3 m diameter) around each large-scale chamber to compare with as-built radon flux measurements and to evaluate the significance of scale effects.

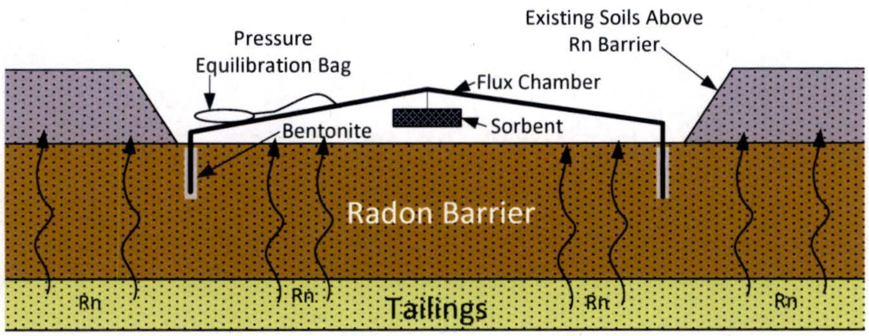

Figure 2. Large-scale Flux Chamber to be Sealed on Radon Barrier Surfaces

We will grout flux chambers to the radon barrier surface with bentonite, attach a Teflon bag to the chamber with Teflon tubing to ensure pressure equilibrium inside and outside the chamber, and coat the interior surface of the chamber with Teflon to avoid radon sorption. We will then replace soils surrounding each flux chamber to ensure a continuous surface boundary. We plan to install chambers during the dry season when the largest radon fluxes are anticipated.

Prior to field testing, we plan to model radon diffusion to determine the appropriate sorption/detection period and mass of sorbent to ensure that chambers will measure radon flux accurately. A one-dimensional analytical model will be used that permits variable source concentration, back diffusion, and decay (e.g., Ferry et al. 2001, Abo-Elmagd 2014). Gaseous diffusivity in the radon barrier will be varied to simulate ranges of water content and macro structure. Effects of back diffusion in closed flux chambers with non-sorbing detectors (i.e., electric passive radon monitor [E-PERM]) will also be simulated. We will conduct sensitivity analysis, varying the source concentration and diffusivity, to assess the range of radon flux that may be encountered in the field and the mass of radon that may accumulate in the flux chamber.

For the first field test, two methods for collecting radon will be compared: (1) activated carbon sorbent and (2) E-PERM. Activated carbon sorbents minimize the potential impacts of back-diffusion, but are subject to variability induced by absorbed moisture. E-PERM is not sensitive to moisture, but radon accumulation within the chamber can result in back diffusion and an underestimate of radon flux (Altic 2011, 2014). For both methods, we will suspend the sorbent or detector for approximately 24 hours (the exact time will depend on the outcomes from the sensitivity analysis). We will flush the flux chamber before switching the carbon sorbent or E-PERM between tests. We will use a diffusion model (e.g., Abo-Elmagd 2014) to examine effects of back diffusion in these first tests. A single method to measure radon accumulation may be chosen moving forward on the basis of these tests.

After completing the radon flux measurement, thin-wall sampling tubes (1 m long, 75 millimeter [mm] diameter) will be pushed in where chambers have been removed to obtain continuous undisturbed samples of the underlying radon barrier. Two tubes will be collected beneath each large-scale chamber and one tube will be collected beneath each conventional-scale chamber.

We will section each tube into 50-mm increments, determine the gravimetric water content and dry unit weight (bulk density) for each increment, and thereby obtain a continuous profile of volumetric water content and water saturation. We will also measure total water potential in each increment using a chilled mirror hygrometer to define a continuous profile of pore water potential. For a second measure of radon, lead-210 sorbed on the radon barrier soil will be measured in the tubes by gamma emission and direct measurement by inductively coupled plasma mass spectrometry following acid extraction. Profiles of sorbed lead-210 can be used as an indicator of Rn flux, as lead-210 is a relatively long-lived (22-year half-life) decay product of radon. Profiles of water saturation will be used to compute diffusivity.

4.2.4 Depth-Dependent Soil Hydraulic Properties

Profiles of soil physical and hydraulic properties will be needed to test hypotheses about depths of soil-forming processes and effects on percolation rates. After completing radon flux tests and removing chambers in a test pit, we plan to collect large-scale (450 mm diameter) undisturbed block samples of the radon barrier in a stacked arrangement (Benson et al. 2011, and ASTM D D7015-13). Once block sampling is complete, we will characterize soil morphology (Soil Survey Staff 1975), including macropore structure, on the sample pit face. Macropore structure will also be mapped using the methods described in Benson et al. (2006).

Each block sample will be trimmed to a diameter of 305 mm in the laboratory for saturated hydraulic conductivity testing using the procedures described in Benson et al. (2011) and ASTM D 5084. Samples of this size are sufficiently large to capture the impacts of soil structural development due to pedogenesis (Benson et al. 2006, 2008, 2011). We will apply an effective stress during hydraulic conductivity testing to simulate the stress that would be encountered at the depth that the block sample was taken. After completing a hydraulic conductivity test, we will measure the soil water characteristic curve (SWCC) of each block sample using a pressure plate method (ASTM D6836). The same large-scale testing apparatus described in Benson et al. (2011) will be used for both the hydraulic conductivity and SWCC tests. This apparatus is sufficiently large to capture features that control liquid and gaseous fluxes in cover soils that have developed macropore structure.

We will use the hydraulic conductivity and SWCC to construct profiles of radon barrier hydraulic properties. These profiles will be compared to either measured or expected hydraulic property profiles documented in engineering and as-built construction reports. We will estimate profiles of gaseous diffusivity on the basis of profiles for SWCCs, pore water potential, and the diffusivity equation in Elberling et al. (1993). These profiles will be compared to the gaseous diffusivity assumed during design of the UMTRCA facility.

4.2.5 Summary of Data Analysis

Several data analysis tools will be used to test study questions and draw conclusions with respect to the project objectives (Section 4.1). Radon fluxes measured and modeled for current radon barrier profile conditions will be statistically compared to estimates as modeled using Regulatory Guide 3.64 (NRC 1989), and as measured at the time of construction, to determine if changes in engineering properties and performance have occurred during a radon barrier's service life. Radon fluxes measured with the large-scale and conventional-scale (smaller-scale) flux chambers in the current study will be compared to each other to determine if a scale-effect exists,

and to quantify the magnitude of the scale effect. We will incorporate any scale effects into the comparison of the fluxes measured in the current study and those measured immediately after construction. Comparison will also be adjusted for differences in soil water content existing immediately after construction and at the time of the current assessment, and for changes in source concentration that may have occurred due to radioactive decay in the underlying tailings since the cover was installed.

Percolation rates will be estimated for each test profile using the program WinUNSAT-H (e.g., Bohnhoff et al. 2009), measured soil hydraulic properties, and site meteorological records. We will use Vadose/W for analysis of sites where snow and a frozen surface may be important. Both WinUNSAT-H and Vadose/W have been shown to provide reliable hydrological predictions when parameterized using realistic hydraulic properties that are representative of field conditions (Ogorzalek et al. 2008, Bohnhoff et al. 2010). We will also estimate percolation using measured or expected hydraulic properties at the time of construction, and then compare the two sets of estimates to assess how the percolation rate may have changed in response to pedogenesis.

4.3 Collaborators

The design, funding, and implementation of this project are products of collaboration between the following researchers and federal agencies:

William Albright, PhD
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Appendix B

Cover Design and Construction Excerpts from Lakeview Final Completion Report

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SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.1 SCOPE

A. This Specification Section describes the requirements for the earthwork related to the construction of the following features:

1. Dust control.
2. Excavation of contaminated materials from the Lakeview Processing Site and construction of the tailings embankment at Collins Ranch Disposal Site.
3. Handling and placing of contaminated material excavated from the vicinity property and delivered at the processing site by others.
4. Construction of vicinity properties encapsulation cell.
5. Construction of temporary and permanent drainage ditches.
6. Construction of retention basins.
7. Construction of decontamination pads.
8. Relocation of Hammersley Creek.
9. Subgrade preparation for decontamination pads and permanent drainage ditches.
10. Finish grading of the sites.

1.2 WORK NOT INCLUDED

A. Earthwork related to the construction of temporary facilities including temporary access roads and haul roads specified in Section 01500 is not included in this Section.

B. Earthwork for pipe trenches is not included in this Section.

1.3 RELATED WORK

A. Section 01300 - Submittals

B. Section 02050 - Demolition

C. Section 02110 - Site Clearing

D. Section 02140 - Dewatering

E. Section 02278 - Erosion Protection

F. Section 02728 - Site Drainage

1.4 DEFINITIONS

A. Excavation: Excavation is defined as excavation required to reach the lines and grades indicated on the Subcontract Drawings or specified herein. It shall include excavation of topsoil, silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders or detached pieces of solid rock; and shall also include removal and reshaping of mill tailings deposits and other contaminated material and final grading of the disposal and processing sites. During the excavation operation, tests to determine any radioactive contamination of the material to be excavated will be performed by the Contractor.

B. Contaminated Materials Excavation: Excavation of contaminated materials, Types 1 and 2, carried out to reach lines and grades indicated on the Subcontract Drawings or as specified herein.

C. Contaminated Materials, Type 1, Excavation: Excavation of contaminated materials from evaporation ponds, and windblown areas within the limits of the site. These materials contain relatively lower levels of radioactive contamination compared to the materials of the tailings pile.

D. Contaminated Materials, Type 2, Excavation: Excavation of contaminated materials from the tailings pile and other areas identified by the Contractor.

E. Uncontaminated Materials Excavation: Excavation of uncontaminated materials including top soil, silt, clay, sand, gravel, talus, soft or disintegrated rock, boulders and removal of detached pieces of solid rock carried out to reach lines and grades indicated on the Subcontract Drawings or specified herein. This excavation shall include

excavations for embankment, drainage ditches, retention basins, trenches, Hammersley Creek and finish grading.

F. Overexcavation: Overexcavation is defined as excavation carried out beyond the lines and grades indicated on the Subcontract Drawings or in the Subcontract Specifications.

G. Slimes: Slimes are the fraction of the tailings consisting of silty clay, clay and clayey silt.

H. Satisfactory Materials: Satisfactory materials for use as fill or backfill shall consist of any material classified by ASTM D2487 as gravels, sands, silts and clays free from roots and other organic matter, trash, debris, frozen materials, and stones larger than 3 inches in any dimension, except as noted hereinafter. Stones with a maximum dimension up to 6 inches will be permitted for fill areas outside of building or pavement locations with 4 inches being the maximum stone dimension allowed in the upper 6 inches of the fill.

I. Unsatisfactory Materials: Unsatisfactory materials shall be materials that do not comply with the requirements for satisfactory materials and materials containing roots and other organic matter, trash, debris, frozen materials, stones that do not meet the dimensional criteria indicated in paragraph 1.4.H, and materials classified by ASTM D2487 as PT, OH, and OL, except as noted hereinbefore.

J. Percent Maximum Density: Percent maximum density is a percentage of the maximum density obtained by the test procedure presented in ASTM D698 and ASTM D1557, as applicable.

K. Topsoil: Topsoil is the existing surface soil stripped to the depth indicated and consisting of natural, friable soil representative of productive soils in the vicinity. Topsoil shall be free of any admixture of subsoil, foreign matter, objects larger than 1 inch in any dimension, toxic substances, and any material or substance that may be harmful to plant growth.

L. Tailings Embankment: Tailings embankment shall consist of a geochemical/flow barrier liner, relocated contaminated materials Types 1 and 2, and the protective cover materials placed and compacted as shown on the Subcontract Drawings and as specifed in this Section.

M. Vicinity Properties Encapsulation Cell: Vicinity properties encapsulation cell consists of embankment constructed

of relocated contaminated wood chips, soils and other materials excavated from vicinity properties, and the protective cover materials as shown on the Subcontract Drawings.

N. Subgrade Preparation: Subgrade preparation includes fine grading and compaction of excavations including drainage ditches, backfills, and embankments upon which pavement, surfacing, base, subbase, bedding materials, riprap, or other structures are to be constructed.

O. Cover: Cover shall consist of the following layers of fill materials placed over the relocated contaminated materials in the tailings embankment as shown on the Subcontract Drawings:

1. Layer of radon barrier materials, and

2. Layers of bedding material and riprap material.

P. Rock-Soil Matrix: Rock-soil matrix shall consist of topsoil placed on the riprap of the top slope of the final tailings embankment filling the surface voids and resulting in a surface ready for seeding.

Q. Handling and placing of contaminated material excavated from the vicinity property and delivered at the processing site by others shall include loading of the material, transportation to the disposal site, placement, compaction and consolidation.

1.5 APPLICABLE PUBLICATIONS

A. The Publications listed below form a part of this Specification to the extent referenced. The Publications are referred to in the text by the basic designation only:

1. American Society for Testing and Materials (ASTM):

ASTM C33-84	Specifications for Concrete Aggregates
ASTM D422-63	Method for Particle-Size Analysis of Soils
ASTM D698-78	Test Methods for Moisture Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb. (2.49-kg) Rammer and 12-in. (305-mm) Drop

ASTM D1140-54	Test Method for Amount of Material in Soils Finer than the No. 200 (75-um) Sieve
ASTM D1556-82	Test Method for Density of Soil in Place by the Sand-Cone Method
ASTM D1557-78	Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb. (4.54-kg) Rammer and 18-in. (457-mm) Drop
ASTM D2167-84	Test Method for Density and Unit Weight of Soil In-Place by the Rubber-Balloon Method
ASTM D2216-80	Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
ASTM D2487-83	Test Method for Classification of Soils for Engineering Purposes
ASTM D2922-81	Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D4318-84	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.6 QUALITY ASSURANCE

A. The Contractor will take soil samples and perform moisture-density, gradation and other tests to ascertain that the work is being performed in compliance with these Specifications. Samples may be taken at the place of excavation, stockpiles, or on the fill itself. The Contractor will conduct the density and other tests on the fill and related laboratory testing as frequently as the Contractor considers necessary. The Subcontractor shall remove surface material and render assistance as necessary to enable sampling and testing.

B. Methods of Sampling and Testing:

1. In-Place Density: ASTM D1556, D2167, or D2922

2. Liquid Limit, Plastic Limit and Plasticity Index: ASTM D4318

3. Particle Size Analysis: ASTM D422

4. Percentage Passing No. 200 Sieve: ASTM D1140

5. Moisture Content: ASTM D2216

6. Laboratory Moisture-Density Relations: ASTM D698, ASTM D1557

7. Soil Classification: ASTM D2487

C. Suitability of Materials: The suitability of all materials for foundations and backfill will be determined by the Contractor. Fill material will be approved material from borrow areas or required excavations.

D. The Contractor may direct that inspection trenches or test pits be cut into fills to determine that the Specifications have been met. Such trenches or pits will be of limited depth and size, and shall be backfilled with the material excavated therefrom, or other fill material meeting the requirements for the zones cut into. Backfill shall be compacted to a density at least equal to that of the contiguous fill.

E. When the Contractor directs inspection trenches or test pits to be excavated into fills and/or backfills and materials are found to meet all Specification requirements, the excavation and refilling shall be paid for as additional work pursuant to the applicable provisions of the General Conditions. Inspection trenches or test pits, and the refilling of the same, shall be at the Subcontractor's expense when it is found that the materials do not meet the Specification requirements.

F. Tolerances: See Specification Section 01052, Article 1.6.

1.7 SUBMITTALS

A. General submittal requirements are specified in Section 01300.

B. The Subcontractor shall submit to the Contractor for approval, 30 days before he intends to dispose of any material in the spoil area, a plan showing the layout of his proposed activities. The plan shall show: location of rock spoil, location of excavated material, stockpile for topsoil, layout of any sediment traps, and any other measures for pollution control.

C. In the event the quantities of radon barrier material are insufficient, the Subcontractor shall submit evidence to the Contractor that radon barrier and rock materials to be used in the cover construction meet the requirements of Article 2.1 below.

1.8 PROTECTION

A. The Subcontractor shall protect the following:

1. Trees, shrubs and other features remaining as a portion of final grading.

2. Bench marks and monuments, existing structures, fences, walks, pavings, curbs, etc. from equipment and vehicular traffic.

3. Above and below ground utilities.

4. Excavations from cave-in by shoring, bracing, sheet-piling, underpinning or by other methods.

5. Bottoms of excavations and soil adjacent to and beneath foundations from frost.

6. Perimeter of excavation top to prevent surface water runoff into excavation.

7. Monitor wells not to be abandoned.

PART 2 - PRODUCTS

2.1 FILL MATERIALS

A. General:

1. Fill materials shall be obtained from required excavations. Additional materials, if required, shall be obtained from approved stockpiles or from other borrow areas selected by the Subcontractor. The Subcontractor shall be responsible for obtaining all required permits and approvals for borrow areas in accordance with the provisions of Section SC-11 of the Special Conditions. Designation of a borrow area does not necessarily indicate that all material within that area meets the Specification requirements specified herein.

2. The Subcontractor shall make his own determination of any processing that may be required, and shall perform testing as required to meet the Specifications for the various construction materials.

3. Application for approval of sources proposed for use by the Subcontractor shall include boring logs, borrow area maps and supporting laboratory test data. The Subcontractor also shall provide evidence of availability, right of access to private property and his plan for hauling the materials to the site. Application for approval of sources for uncontaminated fill materials shall be submitted to the Contractor at least 30 days (60 days for radon barrier materials) before use of the material at the site. In addition, the Contractor shall be granted access to each proposed source to collect samples for testing. The Contractor may perform additional tests to determine if the materials meet the requirements specified herein.

4. Approval will be based on evidence of compliance with the requirements specified herein and on verification by the Subcontractor that the volume of materials available is sufficient for construction requirements.

B. Gradations: Gradations specified shall be as determined after delivery to the site.

C. Uncontaminated Fill Materials:

1. General: [Except for backfill for the processing site,]* uncontaminated fill materials for general fill shall conform to the following requirements:

   a. Maximum particle size shall not be greater than 6 inches.

   b. Uncontaminated fill material, except for demolition debris as described under Article 3.2.A, Section 02050 and except for clearing and stripping debris as described in Section 02110, shall not contain more than 5 percent organic material, by volume, or other deleterious substances.

2. Radon Barrier Materials: Radon barrier materials shall conform to the following requirements:

   a. Radon barrier materials shall be uncontaminated soils obtained from the required disposal site excavation or, if insufficient, from borrow areas

* P.I.D. 13-S-20

approved by the Contractor. The projected Ra-226 content shall not exceed 5.0 pCi/gm.

b. Radon barrier materials shall consist predominantly of soils with classification of CL, MH or ML when classified in accordance with the requirements of ASTM D2487, and graded with maximum particle size of 2 inches and minimum of 50 percent passing No. 200 Sieve. Such materials shall have a Plasticity Index (PI) of 10 or greater when tested according to ASTM D4318. Compliance with these Specifications will be determined by the Contractor.

c. Material shall be compactable to the required density, at all moisture contents within plus three or minus one percent of the optimum moisture content.

d. Radon barrier material shall not contain clearly visible organic matter or other deleterious substances.

3. Geochemical/Flow Barrier Liner Material: The geochemical/flow barrier liner materials shall be select natural uncontaminated silty and clayey materials similar to that for radon barrier obtained from the required disposal site excavation or from other onsite uncontaminated materials excavations or from offsite sources approved by the Contractor.

D. Contaminated Fill Materials:

1. Excavated contaminated materials approved by the Site Manager for use as fill shall be classified into Types 1 and 2 as defined in Article 1.4.

2. Vicinity properties materials delivered by others may include soils, organics, lumber, metals and concrete pieces up to one cubic yard in size.

PART 3 - EXECUTION

3.1 DUST CONTROL

A. Dust control shall consist of furnishing water supply, required equipment, additives, accessories and incidentals, and applying water during the completion of the Subcontract, as required by the Contractor.

B. Water shall be applied in the amounts, at the locations and for the purposes designated in this Specification, and as required by the Contractor.

C. Water shall be applied by means of pressure-type distributors or pipe lines equipped with a spray system or hoses with nozzles that will insure a uniform application of water.

D. All equipment used for the application of water shall be equipped with a positive means of shut-off.

E. Unless otherwise permitted by the Contractor or all the water is applied by means of pipe lines, at least one mobile unit with a minimum capacity of 8,000 gallons shall be available for applying water on the project at all times.

F. The Subcontractor is encouraged to use chemical additives in water. If such additives are used, furnishing and applying the additives shall be at the Subcontractor's expense.

G. The right is reserved by the Contractor to prohibit the use of a particular type of additive, to designate the locations where a particular type of additive may not be used, or to limit the amount of a particular type of additive to be used at certain locations, all if the Contractor has reasonable grounds for believing that such use will be in any way detrimental to the Work.

3.2 EXCAVATION

A. Preparation:

1. Clearing and stripping shall be as specified in Section 02110.

2. Required lines, levels, contours and datum shall be identified before the start of excavation.

3. The Subcontractor shall verify the existing aboveground and underground utilities, identify them, and notify the Contractor immediately of his finding, if any, for appropriate action.

B. General:

1. Before beginning any other excavation work or demolition work in an area, the Subcontractor shall construct the temporary site drainage facilities for such area, as specified in Section 02728.

2. At all times during excavation, the Subcontractor shall conduct his operations in such a manner as to prevent free standing water and contamination of uncontaminated materials. The Subcontractor shall, as a minimum, take the following measures to safeguard against such problems:

   a. Water leaving an excavation area or area otherwise disturbed by construction activities shall be routed into the retention basin as specified in Section 02140.

   b. During seasonal shutdowns, the Subcontractor shall provide labor, materials and equipment as required by the Contractor to maintain and protect exposed surfaces of contaminated material excavations against wind erosion and excessive stormwater erosion. Unless otherwise approved by the Contractor, acceptable methods of erosion protection are as follows:

      1) Spraying water with or without chemical additives. Acceptable chemical additive is "Soil Seal Concentrate" as manufactured by Soil Stabilization Products Company of Merced, California, or approved equal.

      2) Covering exposed surfaces with geotextile fabric such as "Erosion Control Blanket" as manufactured by Soil Stabilization Products Company, or "Supac" as manufactured by Phillips Fibers Corporation of San Jose, California, or approved equal.

3. The Subcontractor shall perform required excavation to the lines and grades indicated on the Subcontract Drawings or as directed by the Contractor. He shall remove all excavated material from the excavation site and dispose of it in the designated spoil areas or use it for other purposes, as approved. In order to avoid contamination of uncontaminated material, the contaminated and uncontaminated materials shall be kept separated during excavation, stockpiling, and placement.

4. Unsuitable or low density subgrade material not readily capable of in-place compaction shall be excavated as directed by the Contractor.

5. Adequate working space for safety of personnel shall be provided within the limits of the excavation.

6. All unstable bottom material shall be removed. Large stones, debris and incompressible soils shall be removed from bottoms of the excavation to a minimum depth of 12 inches. The construction of the geochemical/flow barrier liner is specified in Article 3.7 below.

7. Except as otherwise noted, care shall be exercised to preserve the material below and beyond the lines of all excavation. Where excavation is carried below grade, the Subcontractor shall backfill to the required grade or to indicated invert grade, as specified, and compacted to match the existing conditions.

8. Excavation for the convenience of the Subcontractor shall conform to the limits approved by the Contractor and shall be at no additional expense to the Contractor.

9. Excavated material shall be placed at sufficient distance, but not less than 3 feet, from edge of excavations so as not to cause cave-ins or bank slides.

10. Where practicable, suitable materials removed from excavation shall be used as fill, backfill, or aggregates. The Subcontractor shall test, screen or mix as required and stockpile as specified herein.

11. Excavations for radon barrier and geochemical/flow barrier liner materials shall be carried out in the presence of a qualified technician employed by the Contractor.

C. Contaminated Materials Excavation: Contaminated materials excavation shall include excavation of all contaminated materials from the existing tailings pile, windblown areas, vicinity properties, and the evaporation ponds. The Subcontractor shall minimize the open excavation area of contaminated materials at any time during excavation work. The Subcontractor shall operate from one or two sides at one time, progressing uniformly to opposite sides for completion, unless directed otherwise by the Site Manager. Contaminated materials shall be excavated to the depths indicated on the Subcontract Drawings, or as

required by the Contractor, and placed in the proper location of the tailings embankment at the Disposal Site. The groundwater table fluctuates seasonally, therefore it is recommended that the excavation reaching the lower elevations be delayed until the ground water has receded to the lower levels. If dewatering is necessary, discharge shall be directed to the Retention Basin or Evaporation Pond No. 6 if the retention basin is full. Evaporation Pond No. 1 presently contains wood chips wasted from lumber mill operations. The uncontaminated upper portion of the waste, constituting the larger volume, shall be excavated and placed in the storage pile located on the Subcontract Drawings by others under a separate Subcontract as specified in Section 01010, Article 1.3. The contaminated bottom 12-inch thick portion shall be excavated and placed in the tailings embankment at the disposal site, however, the wood chips shall be distributed so as not to exceed 5 percent by volume in any area of the tailings embankment.

D. Uncontaminated Materials Excavation:

1. General: Uncontaminated materials excavation shall include excavations of uncontaminated materials from the various areas of the site. The excavated materials shall be used as fill in various areas of the site including the construction of berms, dikes, general fill, roadway fill, structure fill, backfill, and fill for the final grading of the site, as required. Uncontaminated excavated material may be stockpiled for later use.

2. Drainage Ditches Excavation:

   a. General: Ditches shall be cut accurately to the cross sections and grades indicated. All roots, stumps, rock, and foreign matter in the sides and bottom of ditches shall be trimmed and dressed or removed to conform to the slope, grade, and shape of section indicated. Care shall be taken not to excavate ditches below the grades indicated. Excessive ditch excavation shall be backfilled to grade with satisfactory, thoroughly compacted material. Ditches shall be maintained until final acceptance of the work.

   b. Temporary Drainage Ditches:

      1) Temporary drainage ditches shall be excavated at locations shown on the Subcontract Drawings to collect and transport storm runoff, wastewater and water-bound contaminated material to the retention basin during construction.

2) Temporary drainage ditches shall be excavated, fine graded, compacted, and maintained to provide drainage during construction.

3) Subgrade of temporary drainage ditches adjacent to the decontamination pads shall be protected with membrane liner from runoff, wastewater and water-bound material during construction. Membrane liner is specified in Specification Section 02771.

c. Permanent Drainage Ditches:

1) Ditches shall be excavated true to line and grade. Any erosion which occurs to ditch excavation before placing erosion protection materials shall be repaired with compacted backfill. All such repairs shall be at Subcontractor's expense and shall not be included in pay quantities, unless otherwise shown on the Subcontract Drawings.

2) The top 6 inches of the subgrade shall be compacted as specified in Article 3.5 below. After compaction has been completed, finish grading shall be done in such a manner that the sideslopes are rendered smooth surfaces. All rocks, brush, roots, large clods, and other objects shall be removed before placement of the bedding material and the riprap material.

3. Retention Basin Excavation: The retention basins shall be constructed to the lines and grades shown on the Subcontract Drawings. The retention basin at the Processing Site shall be located within the approximate limits of existing Evaporation Pond No. 7 which will require two stages of excavation. Contaminated materials shall first be excavated and stockpiled as shown on the Subcontract Drawings, then the excavation and fill for the retention basin shall be accomplished. Seasonal ponding normally occurs at the evaporation ponds until June, after which month they remain dry until the end of the year when precipitation becomes significant. If construction operations cannot be delayed until the dry condition naturally occurs, the Subcontractor shall dewater the area as required to perform the work. Water resulting from dewatering operations shall be discharged to Evaporation Pond No. 6 for eventual evaporation. In no case shall such water be discharged to uncontaminated areas.

4. Borrow Area Excavation:

   a. Where materials are not available in sufficient quantity from the required excavations, such materials shall be obtained from borrow areas of approved sources offsite.

   b. The Subcontractor shall notify the Contractor at least 15 days in advance of opening any borrow area so that adequate time will be allowed for testing the material.

   c. Borrow areas shall meet all permit and negotiated requirements as required by the Contractor.

   d. Necessary clearing, grubbing, and disposal of debris shall be performed by the Subcontractor as incidental operations to the borrow excavation.

   e. Borrow areas shall be neatly trimmed and drained and left in such shape as will facilitate taking accurate measurements after borrow excavations are completed.

3.3 DISPOSAL OF EXCAVATED MATERIALS

A. Contaminated Materials: All contaminated materials excavated from the tailings pile, retention basins, evaporation ponds, and other areas of the site and vicinity properties shall be used in the construction of the tailings embankment and the vicinity properties encapsulation cell as specified herein.

B. Uncontaminated Materials:

   1. Uncontaminated materials excavated from the site, including excavations for trenches, drainage ditches, retention basins, decontamination pads, Hammersley Creek relocation, etc. which do not classify as 3.3.A materials above, shall be used as uncontaminated material fill for construction of various features including site grading, or stockpiled for later use, or wasted in the spoil area, as specified in this Section and as required by the Contractor.

   2. Clean, sound, unweathered rock, of suitable material, from the required excavation may be incorporated into fills, after processing as necessary, provided it meets the requirements specified in this Section.

3. Where used in fills, such material shall be transported directly from the excavation and placed in its final position in such fills whenever possible. If required by the Subcontractor's schedule, the material may be placed temporarily in stockpiles at approved locations. Material in stockpile shall be protected from contamination of any kind that would render it unsuitable for use in fills.

C. Borrow Area Materials: Materials from borrow areas shall be used for final grading of the site and for other uncontaminated material fills as specified in this Section, or as required by the Contractor.

D. Unsatisfactory or Excess Materials: Unsatisfactory and excess excavated uncontaminated material generated during the Work and not approved for use in the Work shall be disposed of in the designated stockpile/spoil areas shown on the Subcontract Drawings.

E. Garbage, refuse, debris, oil, and any waste material which is harmful to the environment or offensive to the area shall be removed from the job site and disposed of offsite in a manner approved by the authority having jurisdiction over the disposal site.

F. All operations in the stockpile/spoil areas throughout the Work shall be in strict conformity with the requirements of this Section. The Subcontractor shall ensure that silty water from the stockpile/spoil areas does not enter nearby waterways. If required, temporary berms and detention ponds shall be constructed by the Subcontractor.

3.4 FILL

A. General Requirements:

1. Clearing and stripping shall be as specified in Section 02110.

2. Fill materials shall be placed and compacted to the lines and grades shown on the Subcontract Drawings or as required by the Contractor.

3. Before commencement of backfill operations, the Subcontractor shall confirm with the Contractor that all contaminated material requiring excavation has been removed.

4. If any portion of the materials does not meet the specified requirements, the Subcontractor shall remove such material and replace it with fill materials meeting the specification at no cost to the Contractor.

5. Fill materials shall be maintained in a manner satisfactory to the Contractor until the final completion and acceptance of the work. This shall include all measures to prevent erosion or contamination during construction, including contamination by radioactive material. In particular, no surface of tailings material shall be left exposed during seasonal or other shutdowns.

B. Placing Requirements:

1. Subgrade preparation shall be as specified in Article 3.5 below.

2. No materials shall be placed on any portion of the subgrade or against or upon any structure until consent to place such fill has been obtained from the Contractor.

3. Fill materials may require moisture conditioning (wetting or drying) prior to compaction. Some tailings slimes particularly will require spreading and extended drying time prior to compaction.

4. Fill materials shall be placed in continuous and approximately horizontal layers for their full length and width unless otherwise specified or specifically permitted by the Contractor.

5. Type 2 contaminated materials excavated from the existing tailings pile shall be placed in the lower layers of the embankment. Type 1 contaminated materials excavated from the evaporation ponds, wastewater retention basins and other windblown areas shall be placed in the upper portions of the tailings embankment.

6. Contaminated materials excavated from the vicinity properties shall be placed in the construction of the vicinity properties encapsulation cell as directed by the Contractor.

7. The method of dumping and spreading the materials shall ensure uniform distribution of the material.

8. The loose thickness of each layer of materials shall not be greater than that required to achieve the required compaction, and in no case shall exceed 12 inches.

9. The Subcontractor shall place material to a grade of 2 percent or steeper to preclude the ponding of water. No fill shall be placed on any area where ponding has been allowed to occur. Where ponding has occurred and the fill material is required to be placed, the water shall be removed and permission for placing of materials shall be obtained prior to placing of materials.

10. Materials shall not be placed on frozen subgrade or embankment material foundations, nor shall frozen material be used as fill.

C. Compaction Requirements:

1. [Each layer of fill materials, except radon barrier, geochemical/flow barrier liner, and processing site backfill containing 30 percent or more retained on 3/4-inch sieve, shall be compacted to a minimum of 90 percent of maximum dry density as determined by ASTM D698. Processing site backfill containing 30 percent or more retained on 3/4-inch sieve shall be compacted by complete coverage of at least two passes of an International Harvester TD-25 bulldozer (or equal).]* Geochemical/flow barrier liner material shall be compacted to at least 95 percent of maximum dry density as determined by ASTM D698. Radon barrier material shall be compacted to at least 100 percent of maximum dry density as determined by ASTM D698.

2. During compaction the moisture content of fill material shall be maintained to achieve specified density. Uniform moisture distribution shall be obtained by disking, blading, or other methods approved by the Contractor prior to compaction of a layer. During compaction of radon barrier materials, moisture content shall be maintained at or greater than optimum moisture as determined by ASTM D698. During compaction of geochemical/flow barrier liner materials, moisture content shall be maintained at or less than optimum moisture as determined by ASTM D698.

3. If the surface of the prepared foundation or the rolled surface of any layer of fill is too dry or too smooth to bond properly with the layer of material to be placed thereon, it shall be scarified and moistened

* P.I.D. 13-S-21

by sprinkling to the acceptable moisture content prior to placement of the next layer of fill.

4. If the rolled surface of any layer of the fill in place is too wet for proper compaction of the layer of fill material to be placed thereon, it shall be removed, allowed to dry or worked with harrow, scarifier, or other suitable equipment to reduce the water content to the required amount, and then re-compacted before the next succeeding layer of fill is placed.

5. Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content shall be reworked to meet the density and moisture requirements or removed and replaced by acceptable fill compacted to meet these requirements.

6. Uncontaminated fill material in the spoil areas shall be placed by spreading with a bulldozer and track walking. Lift thickness before consolidation shall not exceed one foot. Consolidation shall be accomplished by routing of hauling and spreading equipment units.

7. Compaction of radon barrier shall be accomplished by the use of sheep-foot or pneumatic-tired rollers. The final layer of each zoned element shall be compacted by the use of a smooth roller.

D. Field Quality Control:

1. General: The Contractor will take samples and perform tests throughout the construction period, and the Subcontractor shall cooperate in providing access for the Contractor to areas where testing is to be performed and shall schedule his placing to avoid interference with the testing operations.

2. Tests: The Contractor will perform the following tests on a regular basis; these tests are a minimum requirement:

   a. In-place density and moisture content tests, a minimum of one test per 1000 cubic yards of contaminated material placed, and a minimum of one test per 500 cubic yards of each of radon barrier and geochemical/flow barrier liner material placed.

   b. Classification tests, minimum of one test per 2,000 cubic yards of fill placed. This require-

ment shall not be applicable to the placement of contaminated materials.

c. Gradation tests, minimum of one test per 2,000 cubic yards of fill placed. This requirement shall not be applicable to the placement of contaminated materials.

3. The placing and consolidation of the spoil area fills will be subject to the approval of the Contractor.

3.5 SUBGRADE PREPARATION

A. Decontamination Pads:

1. The entire surface of the subgrade shall be plowed, harrowed, and mixed to a depth of at least 6 inches. If subgrade stabilization material is required, it shall be incorporated into the subgrade at this time. After the material has been thoroughly mixed, the subgrade shall be accurately constructed and fine graded to indicated line, grade and contour with all high and low spots eliminated. Compaction shall be carried out for the full width to a depth of 2 1/2 ft. below finished pavement to at least 95 percent of maximum density as determined by ASTM D1557. Soft spots developed during working shall be corrected.

2. Where feasible, pneumatic-tired roller shall be used for compaction, suitable to produce the specified density and moisture content. Where compaction by roller is not feasible, mechanical tampers or vibratory compactors shall be used.

3. Subgrade shall be finished to straightedge or template within specified tolerances with the finished surface bladed to a uniform, dense, smooth texture.

B. Permanent Drainage Ditches: Top 6 inches of the subgrade of each permanent drainage ditch shall be compacted to a minimum of 95 percent of maximum density as determined by ASTM D698. After compaction has been completed, fine finishing shall be done in such a manner that the side-slopes are smooth surfaces. All rocks, brush, roots, large clods, and other objects shall be removed before placement of the bedding materials.

C. Geochemical/Flow Barrier Liner: Prior to placement of geochemical flow barrier liner, the in-place density of

the top 6 inches of the area receiving the fill shall be at least 95 percent of maximum dry density as determined by ASTM D698. If necessary, the surface shall be plowed, harrowed, materials mixed, added or removed, and compacted to obtain the specified density.

D. General Fill:

1. The top 6 inches of the subgrade on which general fill material will be placed shall be compacted to a minimum of 90 percent of maximum dry density as determined by ASTM D698.

2. At the Processing Site, where general fill for site restoration finish grading is to be placed in the Evaporation Ponds and Tailings Pile areas, the final excavation line, as shown on the drawings or as determined by the Contractor, shall be the subgrade for general fill. Within these areas, wherever the subgrade density requirements cannot be achieved, the Site Manager shall be notified and all further work on such subgrade and subsequent placement of initial general fill thereon, shall be as directed by the Contractor.

3.6 RELOCATION OF HAMMERSLEY CREEK (PERMANENT FACILITY)

A. Relocation of Hammersley Creek consists of the following activities:

1. Excavation and embankment of earth along the proposed alignment of the creek.

2. Disposal of excavated materials:

   a. If the excavated materials are found to be uncontaminated materials:

      1) Construction of embankment along the proposed alignment of the creek where required,

      2) Construction of other uncontaminated material fills, or

      3) Wasted in the spoil area, if the excavated materials are found to be excessive.

   b. If the excavated materials are found to be tailings materials:

1) Construction of the tailings embankment at the disposal site.

B. The excavation work and the construction of fills shall conform to the applicable provisions of this Section.

3.7 CONSTRUCTION OF GEOCHEMICAL/FLOW BARRIER LINER

The Geochemical/Flow Barrier Liner shall be constructed using the materials specified in Article 2.1.C.3 above, and compacted to the minimum density specified in Article 3.4 C.1 above.

3.8 ROCK-SOIL MATRIX FOR COVER

A layer of topsoil shall be spread on the riprap of the top slope of the tailings embankment and compacted to force the topsoil to fill the surface voids of the riprap. The uncompacted topsoil layer thickness shall be selected such that after compaction the surface voids in the riprap shall be completely filled. The rock-soil matrix layer shall be maintained and protected from erosion prior to seeding of the surface. The topsoil will be obtained from the stockpile resulting from the stripping operations at the disposal site.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

A. Measurement for payment for the following items of excavations and fills will be by the cubic yards of materials excavated. The quantities for payment will be computed by average end area method from surveys conducted before and after excavation operations as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

1. Excavation of contaminated material from tailings pile, evaporation ponds, windblown areas, and stockpile, including wood chips, and placement in tailings embankment.

2. Excavation and placement of contaminated wood chips in vicinity properties encapsulation cell.

3. Excavation and placement of radon barrier material in vicinity properties encapsulation cell.

4. Excavation of contaminated material from processing site retention basin and Hammersley Creek areas and placement in stockpile.

5. Removal and disposal of excess excavated material from stockpile at Collins Ranch disposal site.

6. Removal of uncontaminated material from the stockpile at the disposal site and placement in vicinity properties encapsulation cell.

7. Excavation of existing uncontaminated material from vicinity properties encapsulation cell area and placement in stockpile.

B. Measurement for payment for the following items of excavations will be by the cubic yards of materials excavated. The quantities for payment will be computed from the lines and dimensions shown on the Subcontract Drawings, or by average end area method from surveys conducted before and after excavation work as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

1. Excavation of uncontaminated material for permanent drainage ditches.

2. Excavation of uncontaminated material for retention basins.

3. Excavation of uncontaminated material for temporary drainage ditches

4. Excavation of uncontaminated material for Hammersley Creek relocation.

5. Excavation of uncontaminated materials at Lakeview Processing site for finish grading.

6. Excavation of uncontaminated material at Collins Ranch Disposal site for finish grading.

7. Excavation of uncontaminated material from tailings embankment area and placement in stock pile, excluding stripping.

C. Measurement for payment for the following items of fills will be by the cubic yards of materials placed in the

fills. The quantities for payment will be computed by the volume the fill material occupies in the final placement location. This volume will be computed from the lines and dimensions shown on the Subcontract Drawings, or by average end area method from surveys conducted before and after placing compacted fills as shown on the Subcontract Drawings, or by the methods determined by the Contractor:

1. Placement of excavated uncontaminated material in fills at Lakeview Processing Site for finish grading including material from disposal site stockpile.

2. Placement of excavated uncontaminated material from stockpile in fills at Collins Ranch Disposal Site for finish grading.

3. Placement of excavated uncontaminated material from stockpile at the disposal site for radon barrier.

4. Placement of excavated uncontaminated material from stockpile at the disposal site for geochemical/flow barrier liner.

5. Placement of uncontaminated material for fills at retention basins.

6. Placement of topsoil on top slope of tailings embankment for rock-soil matrix.

7. Placement of contaminated materials from vicinity properties delivered by others to the disposal site embankment area.

D. Separate measurement for payment will not be made for the following items, and such work will be considered incidental to the related item of work:

1. Dust control.

2. Excavation and backfill of pipe trenches.

3. Subgrade preparation.

4. Excavation and placement of uncontaminated material for decontamination pads.

E. Overexcavation: Overexcavation for the Subcontractor's convenience or due to error or lack of control by the Subcontractor will not be measured for payment and, instead, shall be backfilled with compacted contaminated or uncon-

taminated material fill, as required, at the Subcontractor's expense.

F. Separate measurement for payment will not be made for any other fills specified in this Section.

4.2 PAYMENT

A. Payment for the items of Article 4.1.A above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for excavating, hauling, and placing the excavated materials in their final locations including all grading, shaping, preparing subgrade, compacting or consolidating.

B. Payment for the items of Article 4.1.B above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for excavating and, if required, temporarily stockpiling the materials until final placement.

C. Payment for the items of Article 4.1.C above will be by their applicable unit prices per cubic yard quoted therefor in the Bid Schedule. The prices quoted shall include full compensation for hauling, and placing the excavated materials in their final locations including all grading, shaping, preparing subgrade, compacting or consolidating.

D. Separate payment will not be made for the items mentioned in Article 4.1.D above. All costs for such work will be considered to be included in the price quoted for the related item of work.

E. Separate payment will not be made for any other fills specified in this Section. All costs for furnishing and placing such fills shall be considered to be included in the related items of excavation.

END OF SECTION 02200

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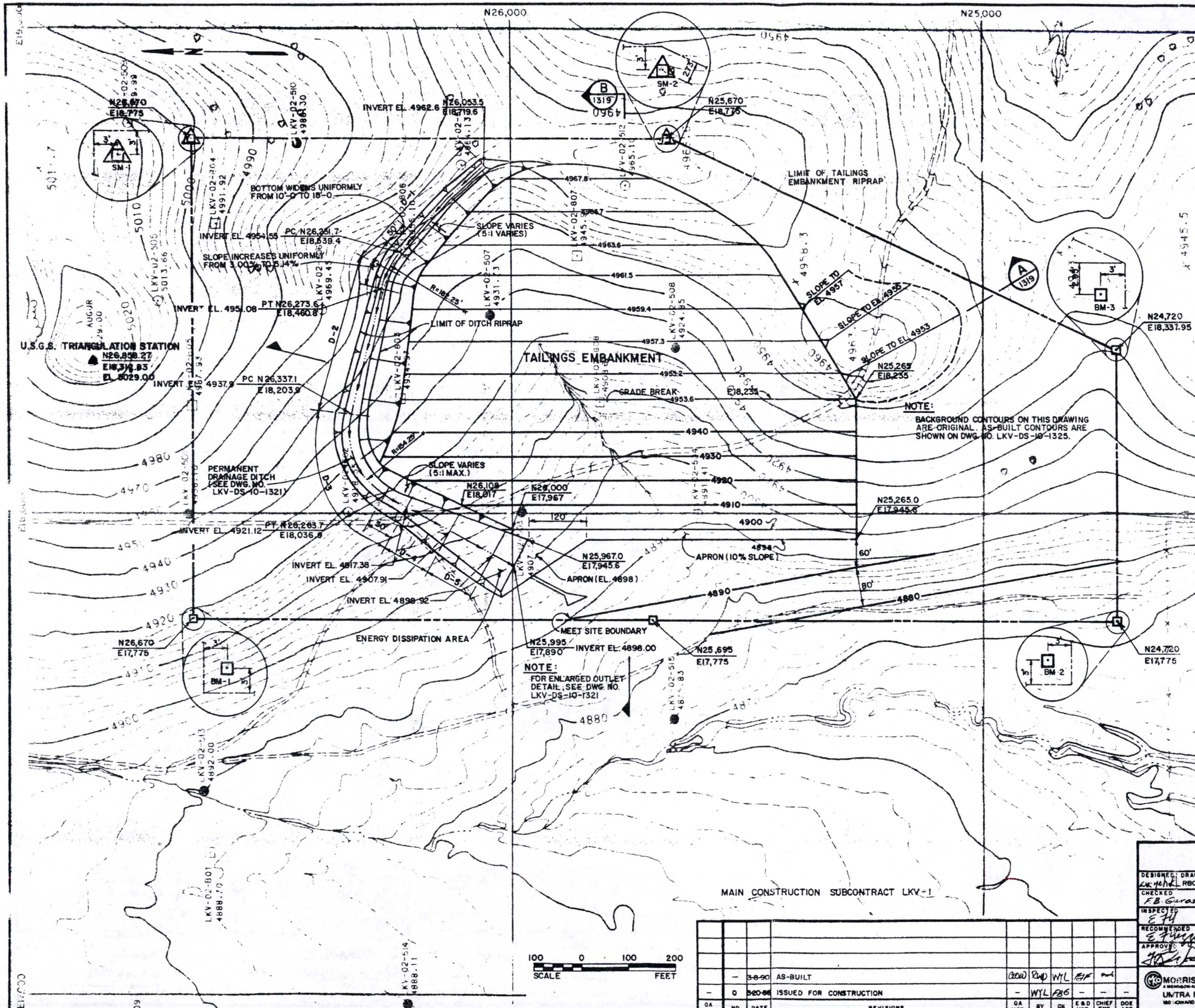


NOTES:

1. FINAL EMBANKMENT TOPSLOPE ELEVATIONS SHALL BE ADJUSTED TO ACCOMODATE ACTUAL QUANTITIES OF MATERIALS PLACED, UPON APPROVAL OF THE CONTRACTOR.
2. PERMANENT BOUNDARY MONUMENTS SHALL BE FURNISHED AND INSTALLED BY THE CONTRACTOR, AND SHALL BE BERNTSEN FEDERAL ALUMINUM SURVEY MONUMENTS MODEL A-1, OR EQUAL.

NOTES (AS-BUILT)

3. FOR AS-BUILT SURFACE CONTOURS REFER TO AS-BUILT TOPOGRAPHIC MAP DWG. NO. LKV-DS-10-1325.
4. MONUMENTS SM-1, SM-2, BM-1, BM-2 AND BM-3 ARE INSIDE THE BOUNDARY AND ARE OFFSET FROM THE CORNERS SHOWN HEREON. SEE DWG. NO. LKV-DS-10-1325 FOR COORDINATES OF AS-BUILT MONUMENTS. COORDINATES SHOWN HEREON ARE FOR BOUNDARY CORNERS.

REFERENCE DRAWINGS.

LKV-DS-10-1313	FINAL SITE PLAN
LKV-DS-10-1316	TAILINGS EMBANKMENT FOUNDATION PLAN
LKV-DS-10-1318	TEMPORARY ACCESS ROAD AND HAUL ROAD
LKV-DS-10-1319	TAILINGS EMBANKMENT SECTIONS & DETAILS
LKV-DS-10-1321	DITCH OUTLET & MONITORING WELL SECTIONS & DETAILS
LKV-DS-10-1325	AS-BUILT TOPOGRAPHIC MAP

LEGEND:

(symbol)	EXISTING SITE FEATURES AND CONTOURS (1982 SURVEY)
(symbol)	SITE BOUNDARY
E18,000	CONSTRUCTION GRID COORDINATES
—4950—	FINISHED GRADE CONTOURS
(symbol)	PERMANENT BOUNDARY MONUMENT
(symbol)	EMBANKMENT
(symbol)	EXCAVATION
(symbol)	PERMANENT BOUNDARY MONUMENT USED AS PERMANENT SURVEY MONUMENT

REGISTERED PROFESSIONAL ENGINEER 9457 OREGON SEPTEMBER 23, 1977 EDWIN S. SMITH

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

LAKEVIEW SITE
LAKEVIEW, OREGON
COLLINS RANCH DISPOSAL SITE

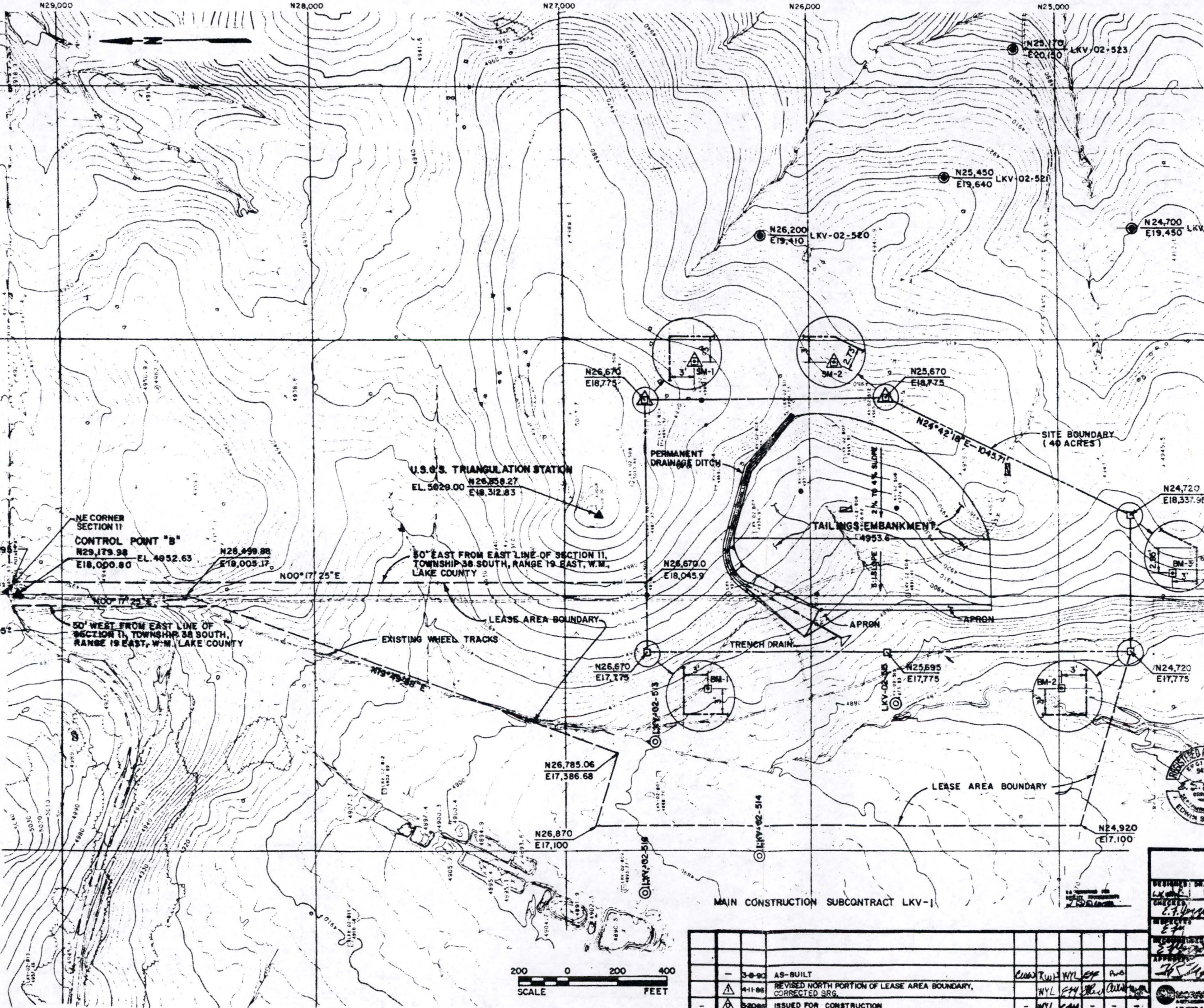
FINAL GRADING PLAN

DESIGNED / DRAWN RBCave
CHECKED F.B. Guros
INSPECTED
RECOMMENDED
APPROVED — DATE 3/19/86 — DOE PROJECT ENGINEER — DATE 3-21-86

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. LKV-DS-10-1317
REV. –

QA MK-F	NO.	DATE	REVISIONS	QA MGR.	BY	CK	E&D MGR.	CHIEF ENG.	DOE APP.
	–	3-8-90	AS-BUILT			WYL			
–	0	3-20-86	ISSUED FOR CONSTRUCTION	–	WYL	FBG	–	–	–



NOTES:

1. PERMANENT SURVEY AND BOUNDARY MONUMENTS WILL BE ESTABLISHED BY THE CONTRACTOR IN THE FIELD. ALL LOCATIONS AND ELEVATIONS SHALL BE REFERENCED TO THE MONUMENTS SHOWN HEREON.
2. SITE MARKERS (2 REQUIRED) SHALL BE FURNISHED AND INSTALLED BY THE CONTRACTOR.
3. GRID SYSTEM IS BASED ON OREGON COORDINATE SYSTEM, SOUTH ZONE. FOR DISPOSAL SITE TRUE COORDINATES, ADD 300,000 NORTH AND 2,000,000 EAST.
4. EXISTING PERMANENT MONITOR WELLS SHALL BE RETAINED AND PROTECTED DURING CONSTRUCTION.

NOTE:(AS-BUILT)

5. LOCATIONS OF SITE MARKERS, MONUMENTS, AND SETTLEMENT PLATES ARE SHOWN ON AS-BUILT TOPOGRAPHIC MAP, DRAWING NO. LKV-DS-10-1325. MONUMENTS SM-1, SM-2, BM-1, BM-2 AND BM-3 ARE LOCATED INSIDE THE SITE BOUNDARY, OFFSET FROM BOUNDARY CORNERS. COORDINATES SHOWN HEREON ARE FOR BOUNDARY CORNERS.

REFERENCE DRAWINGS:

LKV-DS-10-1314,	CONSTRUCTION FACILITIES AND SITE DRAINAGE
LKV-DS-10-1316,	TAILINGS EMBANKMENT FOUNDATION PLAN
LKV-DS-10-1317,	FINAL GRADING PLAN
LKV-DS-10-1318,	ACCESS ROAD AND HAUL ROAD
LKV-DS-10-1319,	TAILINGS EMBANKMENT-SECTIONS & DETAILS
LKV-DS-10-1320,	ACCESS CONTROL, STAGING AREA & MISC.-SECTIONS & DETAILS
LKV-DS-10-1321,	DITCH OUTLET AND MONITORING WELL-SECTIONS & DETAILS

LEGEND:

- EXISTING SITE FEATURES AND CONTOURS (1982 SURVEY)
- SITE BOUNDARY
- E18,000 — CONSTRUCTION GRID COORDINATES
- ℄ OF PERMANENT DRAINAGE DITCH
- PERMANENT BOUNDARY MONUMENT (NOTE 5)
- EXISTING ROAD
- 4950 — FINAL GROUND SURFACE ELEVATION
- 5:1 — SLOPE (HORIZONTAL : VERTICAL)
- PERMANENT MONITOR WELL (NEW)
- PERMANENT SURVEY MONUMENT (INSTALLED BOUNDARY MONUMENT) (NOTE 5)
- SITE MARKER (NOTE 5)
- PERMANENT MONITOR WELL (OLD)

REGISTERED PROFESSIONAL ENGINEER 9457 OREGON — EDWIN S. SMITH

NO.	DATE	REVISIONS	BY
—	3-8-90	AS-BUILT	WYL
1	4-11-86	REVISED NORTH PORTION OF LEASE AREA BOUNDARY, CORRECTED BRG.	WYL
0	3-20-86	ISSUED FOR CONSTRUCTION	WYL

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

LAKEVIEW SITE
LAKEVIEW, OREGON
COLLINS RANCH DISPOSAL SITE

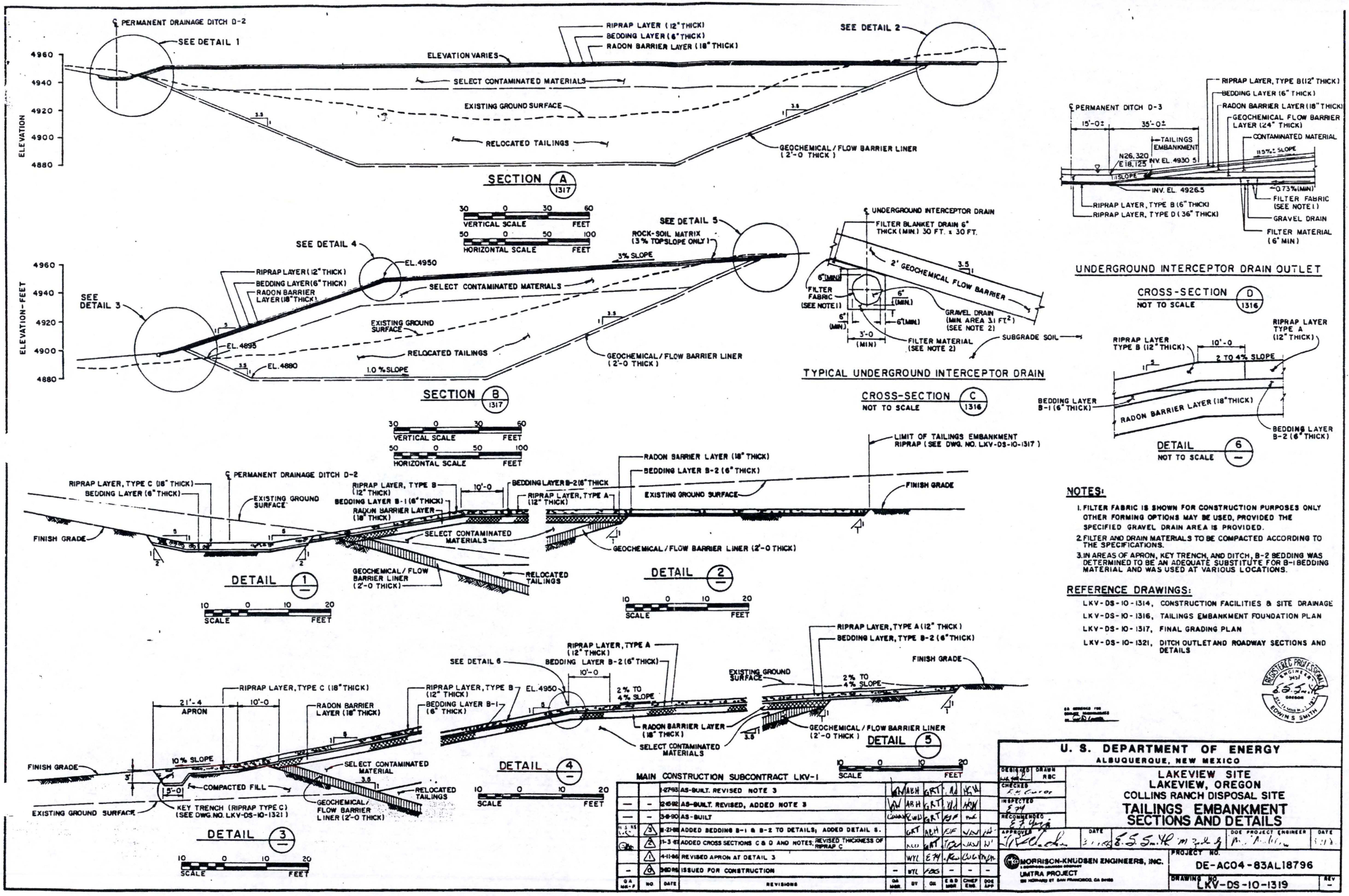
FINAL SITE PLAN

DRAWN: RBC

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

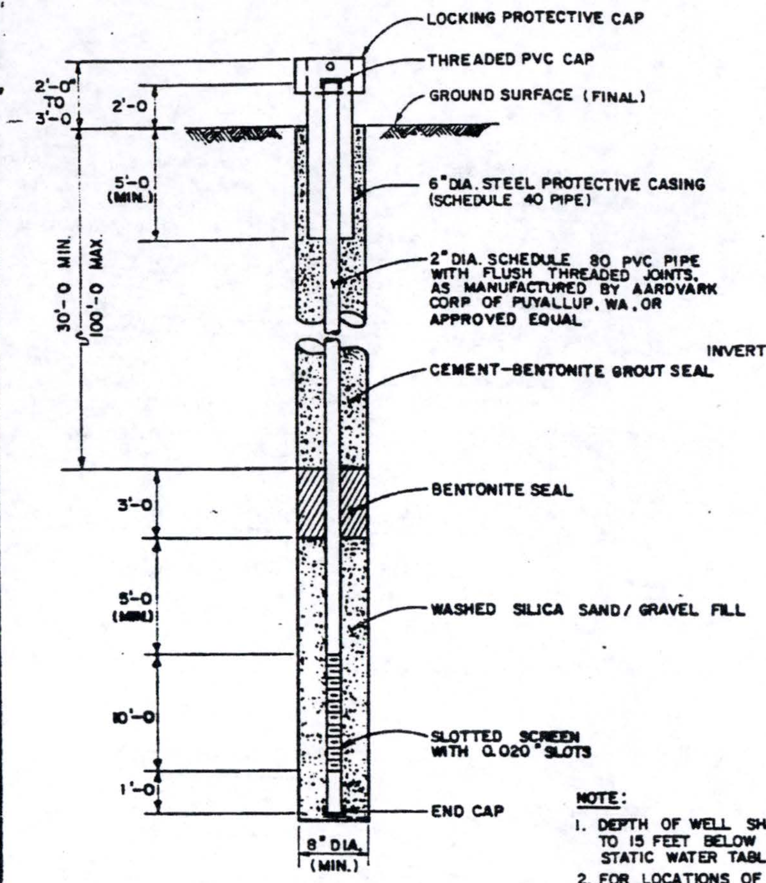
DRAWING NO. LKV-DS-10-1313



PERMANENT DRAINAGE DITCH D-2
SEE DETAIL 1
RIPRAP LAYER (12" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER LAYER (18" THICK)
SEE DETAIL 2
ELEVATION VARIES
SELECT CONTAMINATED MATERIALS
EXISTING GROUND SURFACE
RELOCATED TAILINGS
GEOCHEMICAL / FLOW BARRIER LINER (2'-0 THICK)
ELEVATION
4960
4940
4920
4900
4880
SECTION A 1317
VERTICAL SCALE FEET
HORIZONTAL SCALE FEET
SEE DETAIL 5
ROCK-SOIL MATRIX (3% TOPSLOPE ONLY)
3% SLOPE
SEE DETAIL 4
EL. 4950
RIPRAP LAYER (12" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER LAYER (18" THICK)
SEE DETAIL 3
SELECT CONTAMINATED MATERIALS
EXISTING GROUND SURFACE
EL. 4895
EL. 4880
RELOCATED TAILINGS
1.0 % SLOPE
GEOCHEMICAL / FLOW BARRIER LINER (2'-0 THICK)
ELEVATION-FEET
SECTION B 1317
UNDERGROUND INTERCEPTOR DRAIN
FILTER BLANKET DRAIN 6" THICK (MIN.) 30 FT. x 30 FT.
2' GEOCHEMICAL FLOW BARRIER
FILTER FABRIC (SEE NOTE 1)
GRAVEL DRAIN (MIN. AREA 3.1 FT²) (SEE NOTE 2)
FILTER MATERIAL (SEE NOTE 2)
SUBGRADE SOIL
TYPICAL UNDERGROUND INTERCEPTOR DRAIN
CROSS-SECTION C 1316
NOT TO SCALE
PERMANENT DITCH D-3
15'-0±
35'-0±
TAILINGS EMBANKMENT
N26,320
E18,125
INV. EL. 4930.5
INV. EL. 4926.5
RIPRAP LAYER, TYPE B (12" THICK)
BEDDING LAYER (6" THICK)
RADON BARRIER LAYER (18" THICK)
GEOCHEMICAL FLOW BARRIER LAYER (24" THICK)
CONTAMINATED MATERIAL
RIPRAP LAYER, TYPE B (6" THICK)
RIPRAP LAYER, TYPE D (36" THICK)
FILTER FABRIC (SEE NOTE 1)
GRAVEL DRAIN
FILTER MATERIAL (6" MIN)
UNDERGROUND INTERCEPTOR DRAIN OUTLET
CROSS-SECTION D 1316
NOT TO SCALE
RIPRAP LAYER TYPE B (12" THICK)
RIPRAP LAYER TYPE A (12" THICK)
10'-0
2 TO 4% SLOPE
BEDDING LAYER B-1 (6" THICK)
RADON BARRIER LAYER (18" THICK)
BEDDING LAYER B-2 (6" THICK)
DETAIL 6
NOT TO SCALE
LIMIT OF TAILINGS EMBANKMENT RIPRAP (SEE DWG. NO. LKV-DS-10-1317)
RADON BARRIER LAYER (18" THICK)
BEDDING LAYER B-2 (6" THICK)
EXISTING GROUND SURFACE
FINISH GRADE
RIPRAP LAYER, TYPE C (18" THICK)
BEDDING LAYER (6" THICK)
PERMANENT DRAINAGE DITCH D-2
EXISTING GROUND SURFACE
RIPRAP LAYER, TYPE B (12" THICK)
BEDDING LAYER B-1 (6" THICK)
RADON BARRIER LAYER (18" THICK)
BEDDING LAYER B-2 (6" THICK)
RIPRAP LAYER, TYPE A (12" THICK)
FINISH GRADE
SELECT CONTAMINATED MATERIALS
GEOCHEMICAL / FLOW BARRIER LINER (2'-0 THICK)
RELOCATED TAILINGS
DETAIL 1
DETAIL 2
SCALE FEET
NOTES:
1. FILTER FABRIC IS SHOWN FOR CONSTRUCTION PURPOSES ONLY OTHER FORMING OPTIONS MAY BE USED, PROVIDED THE SPECIFIED GRAVEL DRAIN AREA IS PROVIDED.
2. FILTER AND DRAIN MATERIALS TO BE COMPACTED ACCORDING TO THE SPECIFICATIONS.
3. IN AREAS OF APRON, KEY TRENCH, AND DITCH, B-2 BEDDING WAS DETERMINED TO BE AN ADEQUATE SUBSTITUTE FOR B-1 BEDDING MATERIAL AND WAS USED AT VARIOUS LOCATIONS.
REFERENCE DRAWINGS:
LKV-DS-10-1314, CONSTRUCTION FACILITIES & SITE DRAINAGE
LKV-DS-10-1316, TAILINGS EMBANKMENT FOUNDATION PLAN
LKV-DS-10-1317, FINAL GRADING PLAN
LKV-DS-10-1321, DITCH OUTLET AND ROADWAY SECTIONS AND DETAILS
RIPRAP LAYER, TYPE A (12" THICK)
BEDDING LAYER, TYPE B-2 (6" THICK)
RIPRAP LAYER, TYPE A (12" THICK)
BEDDING LAYER B-2 (6" THICK)
SEE DETAIL 6
FINISH GRADE
EXISTING GROUND SURFACE
2% TO 4% SLOPE
RIPRAP LAYER, TYPE C (18" THICK)
21'-4 APRON
10'-0
RADON BARRIER LAYER (18" THICK)
RIPRAP LAYER, TYPE B (12" THICK)
BEDDING LAYER B-1 (6" THICK)
EL. 4950
RADON BARRIER LAYER (18" THICK)
SELECT CONTAMINATED MATERIALS
GEOCHEMICAL / FLOW BARRIER LINER (2'-0 THICK)
DETAIL 5
FINISH GRADE
10% SLOPE
SELECT CONTAMINATED MATERIAL
COMPACTED FILL
5'-0
RELOCATED TAILINGS
EXISTING GROUND SURFACE
KEY TRENCH (RIPRAP TYPE C) (SEE DWG. NO. LKV-DS-10-1321)
GEOCHEMICAL/ FLOW BARRIER LINER (2'-0 THICK)
DETAIL 3
DETAIL 4
MAIN CONSTRUCTION SUBCONTRACT LKV-1
AS-BUILT. REVISED NOTE 3
AS-BUILT. REVISED, ADDED NOTE 3
AS-BUILT
ADDED BEDDING B-1 & B-2 TO DETAILS; ADDED DETAIL 6.
ADDED CROSS SECTIONS C & D AND NOTES; REVISED THICKNESS OF RIPRAP C
REVISED APRON AT DETAIL 3
ISSUED FOR CONSTRUCTION
REVISIONS
REGISTERED PROFESSIONAL ENGINEER OREGON EDWIN S. SMITH
U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
LAKEVIEW SITE
LAKEVIEW, OREGON
COLLINS RANCH DISPOSAL SITE
TAILINGS EMBANKMENT SECTIONS AND DETAILS
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
PROJECT NO. DE-AC04-83AL18796
DRAWING NO. LKV-DS-10-1319

NOTES:

1. LOCATIONS OF PERMANENT DRAINAGE DITCHES ARE SHOWN ON DWG. NO. LKV-DS-10-1317. CROSS-SECTION DATA AND RIPRAP MATERIALS FOR THE DITCHES ARE AS SHOWN BELOW:
2. IN AREAS OF APRON, KEY TRENCH, AND DITCH, B-2 BEDDING WAS DETERMINED TO BE AN ADEQUATE SUBSTITUTE FOR B-1 BEDDING MATERIAL AND WAS USED AT VARIOUS LOCATIONS.

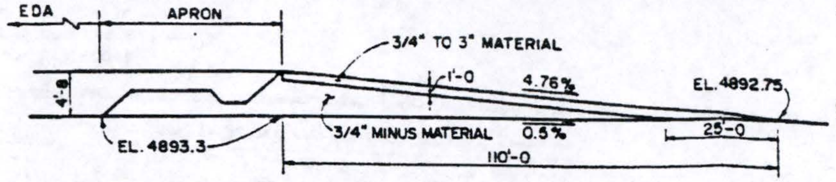


NOTE:

1. DEPTH OF WELL SHALL EXTEND TO 15 FEET BELOW DRY SEASON STATIC WATER TABLE SURFACE.
2. FOR LOCATIONS OF PERMANENT MONITOR WELLS SEE DWG. NO. LKV-DS-10-1313.

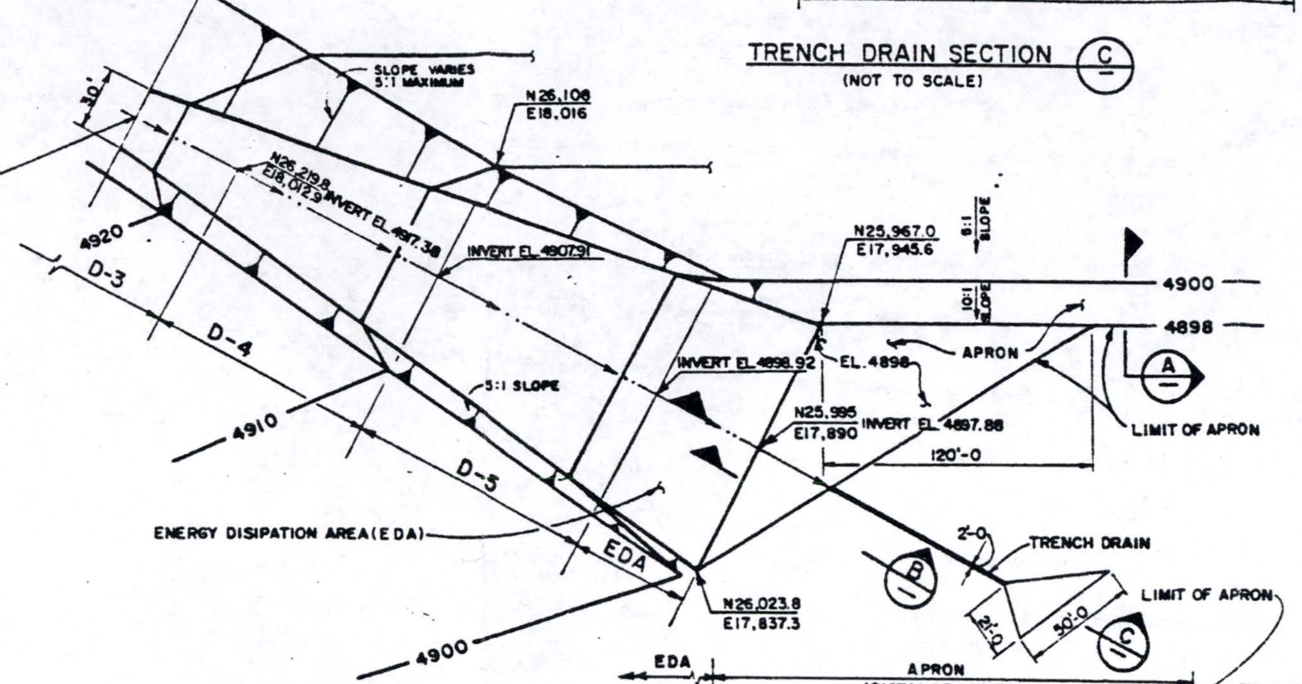
TYPICAL MONITORING-WELL INSTALLATION DETAIL

(NOT TO SCALE)

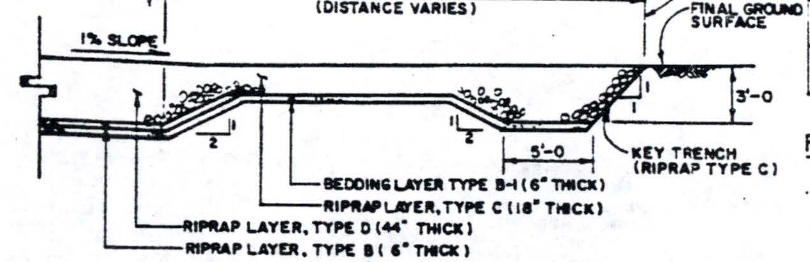


TRENCH DRAIN SECTION (C)

(NOT TO SCALE)



DITCH OUTLET DETAIL (1/1317)



TYPICAL DITCH OUTLET SECTION (B)

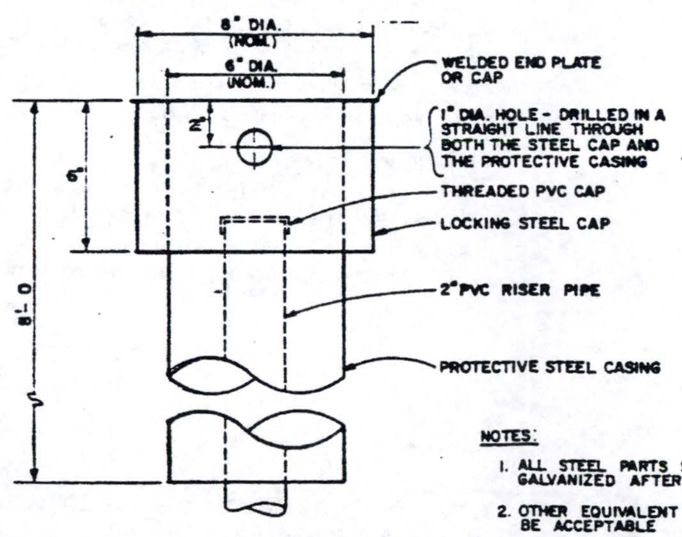
(NOT TO SCALE)

DITCH RIPRAP DATA

DITCH	℄ LOCATION	W	D	S	RIPRAP TYPE AND THICKNESS
D-1	N26,053.5 / E18,719.6	10	2	5+	R-1 = TYPE C/18"
.	N26,198.1 / E18,576.4	10	2	5+	R-2 = NONE
	N26,231.7 / E18,539.4	15	2	5+	
D-2	N26,257.6 / E18,502.6	15	2	5+	
	N26,335.8 / E18,209.2	30	2	5+	
D-3	N26,337.1 / E18,203.9	30	2	5+	R-1=TYPE D/44"
	N26,263.7 / E18,036.9	30	2	12+	R-2=TYPE B/6"
	N26,219.8 / E18,012.9	44.5	2	18±	
D-4	N26,219.8 / E18,012.9	44.5	2	18±	
	N26,132.0 / E17,964.9	73.5	2	10±	
D-5	N26,132.0 / E17,964.9	73.5	2	10±	
	N26,038.9 / E17,914.0	105.5	1.5	10±	
E.D.A.	N26,038.9 / E17,914.0	105.5	1.5	5+	
	N25,995 / E17,890	120	1	-	

REFERENCE DRAWINGS:

- LKV-DS-10-1313 FINAL SITE PLAN
- LKV-DS-10-1317 FINAL GRADING PLAN

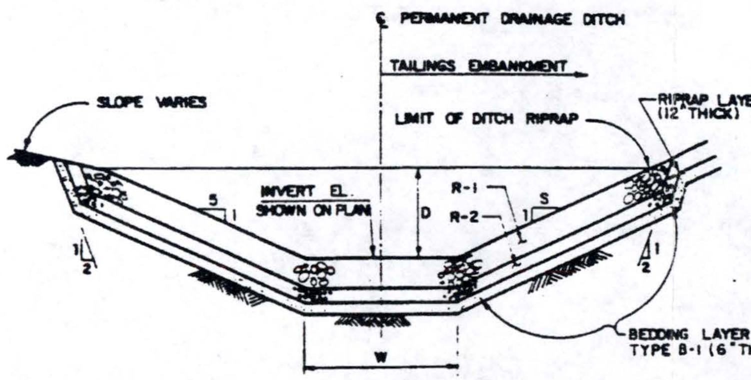


NOTES:

1. ALL STEEL PARTS SHALL BE HOT-DIPPED GALVANIZED AFTER FABRICATION
2. OTHER EQUIVALENT LOCKING CAPS WILL BE ACCEPTABLE
3. 7/8" DIA. STEEL LOCKING BAR SHALL BE FURNISHED TO SUIT.

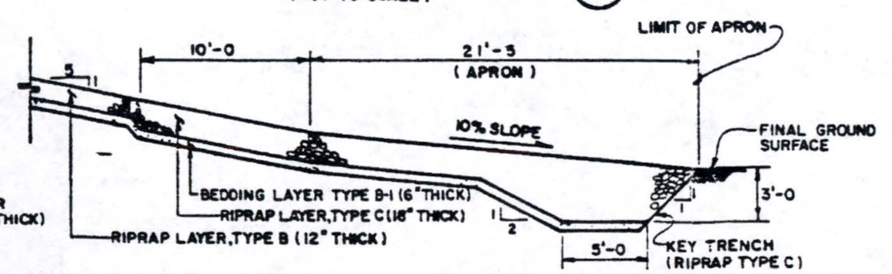
TYPICAL LOCKING PROTECTIVE CAP DETAIL

(NOT TO SCALE)



TYPICAL PERMANENT DITCH SECTION

(NOT TO SCALE)



TYPICAL APRON KEY TRENCH SECTION (A)

(NOT TO SCALE)

REGISTERED PROFESSIONAL ENGINEER 9457 OREGON SEPTEMBER 23, 1977 EDWIN S SMITH

MAIN CONSTRUCTION SUBCONTRACT LKV-1

QA MK-F	NO	DATE	REVISIONS	QA MGR	BY	CK	E&D MGR	CHIEF ENG	DOE APP
		1-27-93	AS-BUILT, REVISED NOTES 1 & 2						
	—	12-15-92	AS-BUILT, REVISED, ADDED NOTE 2						
	—	3-8-90	AS-BUILT						
	4	10-21-88	ADDED BEDDING B-1 TO SECTIONS						
	3	11-3-87	REVISED THICKNESS OF RIPRAP LAYERS TYPE C & D						
—	2	8-4-86	REVISED MONITOR WELL SCREEN SLOT SIZE						
—	1	4-11-86	REVISED EROSION PROTECTION AT EDA & APRON						
—	0	3-10-86	ISSUED FOR CONSTRUCTION	—			—	—	—

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED | DRAWN RBCove
CHECKED
INSPECTED
RECOMMENDED
APPROVED | DATE | DOE PROJECT ENGINEER | DATE

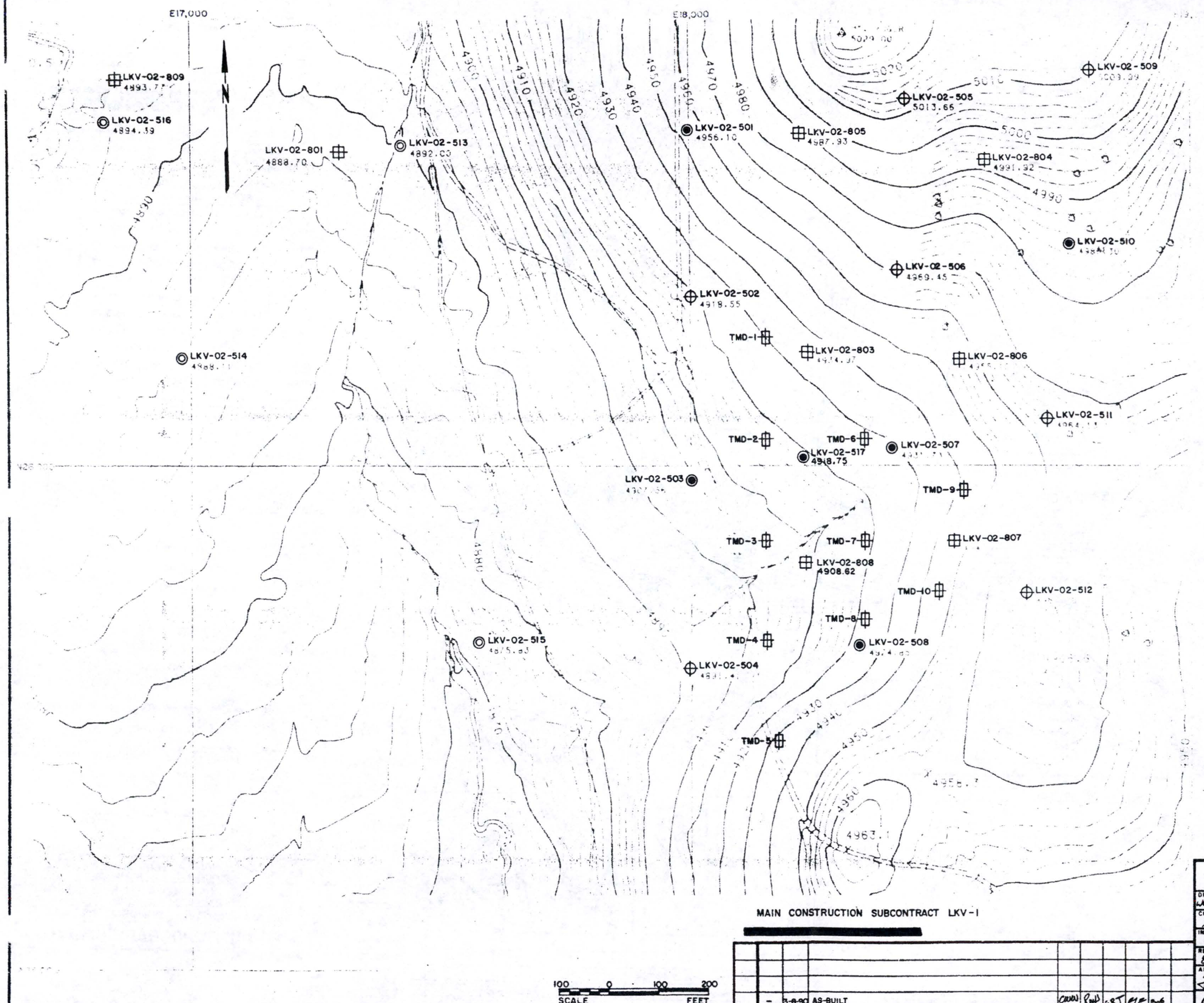
LAKEVIEW SITE
LAKEVIEW, OREGON
COLLINS RANCH DISPOSAL SITE

DITCH OUTLET & MONITORING WELL SECTIONS AND DETAILS

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. LKV-DS-10-1321 REV —



NOTES:

1. GROUND WATER DATA AND SUBSURFACE EXPLORATION LOGS ARE AVAILABLE IN INFORMATION TO BIDDERS.
2. FOR MONITOR WELLS TO BE ABANDONED AND SEALED, SEE TABLE 02090-1, SECTION 02090 OF THE SUBCONTRACT SPECIFICATIONS. MONITOR WELLS THAT ARE NOT ABANDONED SHALL BE SAVED AND PROTECTED DURING CONSTRUCTION.

NOTE: (AS-BUILT)

3. MONITOR WELLS LKV-02-501, LKV-02-503, LKV-02-507, LKV-02-508, LKV-02-510 AND LKV-02-517 WERE ABANDONED AND SEALED.

REFERENCE DRAWINGS:

LKV-DS-10-1314 CONSTRUCTION FACILITIES AND SITE DRAINAGE

LEGEND:

◎ LKV-02-510	MONITOR WELL INSTALLED IN 1984 & 1985
⊕ LKV-02-509	AUGER BORING DUG IN 1984
⊞ LKV-02-804	TEST PIT DUG IN 1984
⊞ TMD-10	TEST PIT DUG IN 1985
◉ LKV-02-510	MONITOR WELL SEALED IN 1986

REGISTERED PROFESSIONAL ENGINEER 3457 OREGON SEPTEMBER 23, 1977 EDWIN S. SMITH

MAIN CONSTRUCTION SUBCONTRACT LKV-1

QA MK-F	NO.	DATE	REVISIONS	QA MGR.	BY	CK	E&D MGR.	CHIEF ENG.	DOE APP.
	-	3-8-90	AS-BUILT			GRT			
-	0	3-20-86	ISSUED FOR CONSTRUCTION	-	WYL	FBG	-	-	-

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

LAKEVIEW SITE
LAKEVIEW, OREGON
COLLINS RANCH DISPOSAL SITE

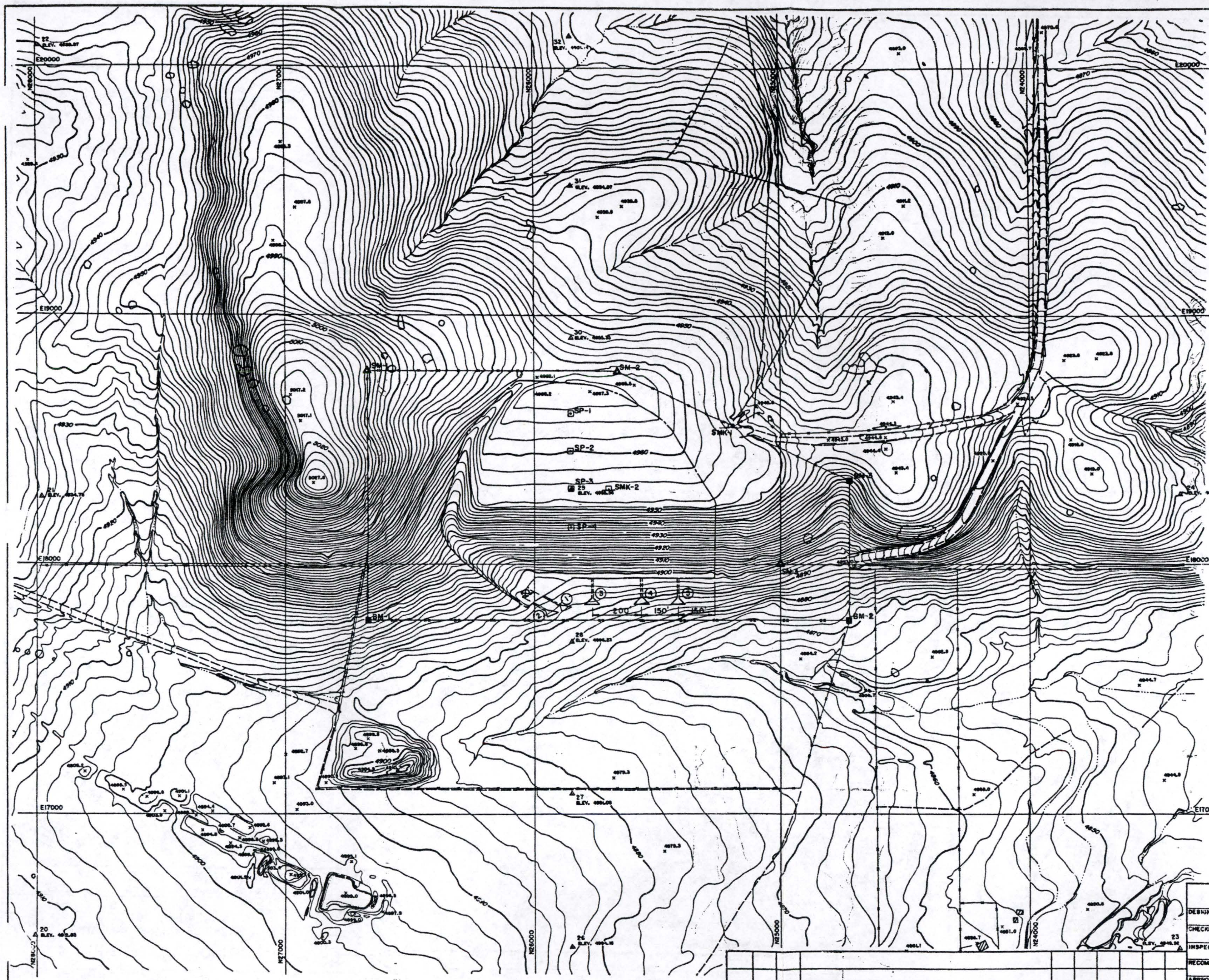
BORING LOCATION PLAN

DESIGNED | DRAWN RBC | CHECKED F.B. | INSPECTED | RECOMMENDED | APPROVED | DATE 3-19-86 | DOE PROJECT ENGINEER | DATE 3-21-86

MORRISON-KNUDSEN ENGINEERS, INC.
A MORRISON-KNUDSEN COMPANY
UMTRA PROJECT
180 HOWARD ST. SAN FRANCISCO, CA 94105

PROJECT NO. DE-AC04-83AL18796

DRAWING NO. LKV-DS-10-1322 REV. -



NOTES:

1. SURVEY BY ADKINS CONSULTING ENGINEERS, INC., KLAMATH FALLS, OREGON.
2. MONUMENTS SM-1, SM-2, BM-1, BM-2, AND BM-3 ARE LOCATED INSIDE THE SITE BOUNDARY, OFFSET FROM BOUNDARY CORNERS. SEE DRAWING NO. LKV-DS-10-1313 FOR BOUNDARY CORNER COORDINATES.
3. ON OCTOBER 19, 1990, EROSION CONTROL FABRIC WAS INSTALLED AS FOLLOWS: 65-FT. WIDE ON 5:1 SLOPE 3 FT. FROM S. EDGE OF CELL; 50-FT. LONG x 50-FT. WIDE AT OUTLET OF EACH OF FIVE TRENCH DRAINS WEST OF CELL.
4. CROSS-SECTION OF TRENCH DRAIN NO. 1 IS SHOWN ON DWG. NO. LKV-DS-10-1321. CROSS-SECTIONS OF TRENCH DRAINS NO. 2 TO 5 ARE THE SAME AS NO. 1 EXCEPT FOR ADDITION OF 4-IN. DIA. SCHEDULE 40 PVC PIPE WITH 0.02-IN. SLOTS AT 0.125-IN. SPACING LOCATED 2-IN. ABOVE BASE OF TRENCH.

LOCATION AND ELEVATION OF MONUMENTS, MARKERS AND SETTLEMENT PLATES

LOCATION	NORTHING	EASTING	ELEVATION	NOTE
SM-1*	26,667.00	18,772.00	5002.00	TOP OF SURVEY CAP
SM-2*	25,670.00	18,772.00	4964.20	↓
SM-3	25,000.00	18,000.00	4900.21	↓
BM-1*	26,667.00	17,778.00	4919.27	↓
BM-2*	24,723.00	17,778.00	4872.47	↓
BM-3*	24,723.00	18,335.00	4931.18	↓
SMK-1	25,200.50	18,553.50	4953.18	TOP NE CORNER
SMK-2	25,700.00	18,300.00	4957.13	TOP NE CORNER
SP-1	25,850.00	18,600.00	4965.50	TOP OF PLATE
SP-2	25,850.00	18,450.00	4960.31	↓
SP-3	25,850.00	18,300.00	4955.58	↓
SP-4	25,850.00	18,150.00	4936.69	↓

* REFERENCE MONUMENT

5. PROPOSED FENCE SECTION TO BE INSTALLED AS A RESULT OF A CONCERN OF ODOE TO PREVENT CATTLE ACCESS TO DISPOSAL SITE.

LEGEND:

- ROAD
- TRAIL OR CLEARED LINE
- LIMIT OF RIPRAP
- FENCE (EXISTING)
- ×4953.6 SPOT ELEVATION
- 30 ELEV. 4955.35 SURVEY CONTROL POINT
- SM-1 SURVEY MONUMENT
- BM-1 BOUNDARY MONUMENT
- SMK-1 SITE MARKER
- SP-1 SETTLEMENT PLATE
- TRENCH DRAIN NO. 1 (SEE NOTE 4)
- PROPOSED FENCE (TO BE INSTALLED DURING THE SPRING OF 1992)

200 0 200 400
SCALE FEET

PHOTOGRAMMETRY BY CASCADE AERIAL MAPS AND SURVEYS, INC.
PHOTOGRAPHY DATED 11-22-89

QA DOC-F	NO.	DATE	REVISIONS	BY	CK	ENG MGR.	CHIEF ENG.	QA MGR.	DOE APP.
	—	3-4-92	ADDED PROPOSED FENCE & NOTE 5						
	—	12-17-90	AS-BUILT (REVISED)	RSL	GRT	DM	ESS		
	—	5-8-90	AS-BUILT		GRT	FJF			

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DESIGNED | DRAWN SH
CHECKED
INSPECTED
RECOMMENDED
APPROVED | DATE | DOE PROJECT ENGINEER | DATE

LAKEVIEW SITE
LAKEVIEW, OREGON
COLLINS RANCH DISPOSAL SITE

FINAL TOPOGRAPHIC MAP

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83AL18796
DRAWING NO. LKV-DS-10-1325
REV. —

Appendix C

Restoration Process and Monitoring Details with Contingency Planning

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C1.0 Overview

This appendix pertains to *Effects of Soil-Forming Processes on Cover Engineering Properties, Field Work Plan, Lakeview, Oregon, Disposal Site,* Section 2.1.10 through Section 2.1.12, which describe restoring the radon barrier, measuring radon flux on the restored radon barrier, and replacing layers overlaying test sites. This addendum provides some additional detail on the restoration-related workflow process and a path forward if it is not possible to meet any original cover construction design specifications during cover restoration.

The following detailed steps are planned at the Lakeview site before and during poststudy cover restoration to meet the original design specification developed for the construction of the entire cover. This Work Plan will apply full-scale design criteria and specifications to the restoration of small-scale study excavations. If test pits encounter layer thicknesses greater than or less than design specifications, the adjacent layer thickness will be matched during restoration, replacing and compacting the same volume removed to avoid leaving a depression or mound.

Additionally, the approach used for implementing the project and all personnel will strive to minimize land disturbances caused at this site as a result of conducting this study.

C2.0 Radon Barrier Layer Restoration

[1] During the initial days of disposal cover excavations, the designated geotechnical testing subcontractor will perform at least one measurement of dry density and moisture content using both the nuclear method (ASTM D2922-81 and D3017-78) and sand cone density and laboratory moisture methods (ASTM D-1556-82 and ASTM D-2216-80) on the existing radon barrier surface. The subcontractor will also obtain field samples of the radon barrier to conduct expedited laboratory tests that include (1) a standard proctor (ASTM D-698) and (2) a modified proctor (ASTM D-1557).

[2] Radon barrier placement specifications state that the loose thickness of each layer shall not be greater than that required to achieve the required compaction and in no case shall exceed 12 inches. Due to the small excavation area, lifts shall be 4- to 6-inch-thick compacted lifts, meeting a compaction density of at least 100% of the maximum dry density and a moisture content within −1% to +3% of the optimal moisture content as determined by ASTM D698. Compaction will be performed using hand-held mechanical compaction equipment such as a jumping jack-style compactor or rammer. If adjacent radon barrier thickness is found to be greater than the expected 18-inch thickness, four equal lifts will be implemented; for thicknesses less than the expected 18-inches, three equal lifts will be implemented. The top of the final lift will be left flush with the adjacent radon barrier surface.

[3] Once proctor results are available and field compaction testing with the nuclear method on the first compacted radon barrier lift at two or more locations is completed, the project engineer and field and site leads will discuss results, then follow step 4 or 5 based on that discussion.

[4] If the initial tests show good correlation between the two density methods and compaction of the first lift passes the minimum requirements based on the standard proctor, then cover

restoration may continue as specified in this Work Plan following the original cover design.

[5] Conversely, if specifications cannot be achieved, a conference call will be conducted to discuss the results of the field measurements and determine the best path forward with respect to the remaining cover restoration. The call will include the LMS project engineer and field and site leads, as well as DOE and NRC representatives able to evaluate and concur, or nonconcur, with any proposed field changes that may be necessary. Additionally, if problems occur with correlation between the compaction test methods, then the team will discuss the best path forward to restore the cover to satisfactory conditions. This could involve reexcavation of the lift failing to meet placement specifications.

[6] Cover restoration of the radon barrier will continue with the subsequent 4- to 6-inch compacted lifts per this Work Plan unless otherwise specified by field changes agreed to as discussed above. An additional restored lift will be tested using either a sand cone method (ASTM D-1556) or nuclear gauge method (ASTM D-2922/D-3017) if correlations agree or per the field change agreement as discussed above.

[7] The moisture-density relationship of clayey soils requires the controlled addition of water so as not to exceed the optimum moisture content too quickly and miss the ability to achieve proper compaction. During cover restoration, additional care and time will be put forth to incrementally add smaller amounts of water by means of a sprayer and rake. The volume of soils removed will be documented and replaced with an equal amount of soil. As specified in the Work Plan, Section 2.11, postrestoration radon flux measurements will be collected directly above each former radon barrier excavation.

C3.0 Bedding Layer Restoration

[8] Cover restoration for the bedding layer will also involve using the same hand-held mechanical compaction equipment to restore the 6-inch compacted single lift. The bedding material shall be placed in the excavation and compacted by four passes of a mechanical rammer compactor.

C4.0 Rock Riprap Layer (on side slopes) Restoration

[9] Cover restoration for the 12-inch rock riprap layers will involve pulling the segregated excavated materials back into the excavation footprint. Actual layer thicknesses encountered will be restored so no mounding or depressions are present. The tracked mini-excavator will be used to smooth over the surface flush with the adjacent surface.

C5.0 Rock and Soil Matrix with Vegetation Layer (on top slope) Restoration

[10] Cover restoration for the 12-inch-thick rock and soil matrix with vegetation layer will involve pulling the segregated excavated materials back into the excavation footprint with vegetation on top. Compact with a rammer to force the soil into the voids. Compaction shall be deemed complete by visual inspection when all surface voids in the rock are completely filled. No testing will be required. The seed mixture in Table C-1, will be hand broadcast and raked in over the disturbed area. The tracked mini-excavator will be driven over the seeded area, leaving the soil in a rough, pitted condition to promote water retention and seed germination.

Table C-1. Seed Mixture for Lakeview Disposal Site

***Scientific Name*/Common Name**	**Variety**	**Broadcast Rate (PLS lbs/acre)**
Pascopyrum smithii Western wheatgrass	Rosana or Arriba	3.0
Elymus elymoides Bottlebrush squirreltail		2.0
Achnatherum hymenoides Indian ricegrass	Nezpar	3.0
Artemisia frigida Prairie sagewort		0.25
Aster chilensis Pacific aster		0.25
Erigeron speciosus Aspen daisy		0.25
Eriogonum umbellatum Sulfur flower		2.0
Hedysarum boreale Northern sweetvetch		3.0
Linum lewisii Lewis blue flax		2.0
Oenothera pallida White evening primrose		1.0
Sphaeralcea coccinea Scarlet globemallow		0.5
Total		**17.25**

Abbreviation:
PLS lbs/acre = pure live seed pounds per acre

C6.0 Follow Up

The potential exists for other field change needs due to unknown or unexpected conditions observed or experienced in the field, which is partially the basis for this study. Upon encountering an activity that may require deviation from the approved Work Plan, additional communication will be necessary between the LMS team, DOE, and NRC during this mobilization (this may include weekend correspondence with leads or alternates that can be arranged ahead of time) as follows:

- Identify the issue and potential resolution
- Redline the Work Plan section(s) with proposed field changes
- Initiate communication via conference call or email with engineers and leads from the LMS team with DOE and NRC representatives having authority to concur, or nonconcur, with proposed field design changes
- Document the agreed-upon solution
- Include details in cover restoration completion report

Future inspections will revisit these sites to look for and address any subsidence. Detailed notes, measurements, and photos will be taken to document all restoration activities and included in a postrestoration report for this site.