Accelerated Pilot Project for U Canyon Demolition – 11434

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ABSTRACT

At the U.S. Department of Energy's (DOE) Hanford Site in southeast Washington State, CH2M HILL Plateau Remediation Company (CH2M HILL) is underway on a first-of-a-kind project with the decommissioning and demolition of the U Canyon. Following the U.S. Environmental Protection Agency's Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Record of Decision for the final remediation of the canyon, CH2M HILL is combining old and new technology and techniques to prepare U Canyon for demolition. The selected remedial action called first for consolidating and grouting equipment currently in the canyon into lower levels of the plant (openings called cells), after which the cell galleries, hot pipe trench, ventilation tunnel, drains and other voids below the operating deck and crane-way deck levels will be filled with approximately 20,000 cubic yards of grout and the canyon roof and walls demolished down to the approximate level of the canyon deck. The remaining canyon structure will then be buried beneath an engineered barrier designed to control potential contaminant migration for a 500-year life. Methods and lessons learned from this project will set the stage for the future demolition of Hanford's four other canyon-type processing facilities.

Fig. 1: The 221-U Canyon Facility at the Hanford Site, as CH2M HILL D&D workers prepare the site for placement of fill for the canyon's eventual demolition.

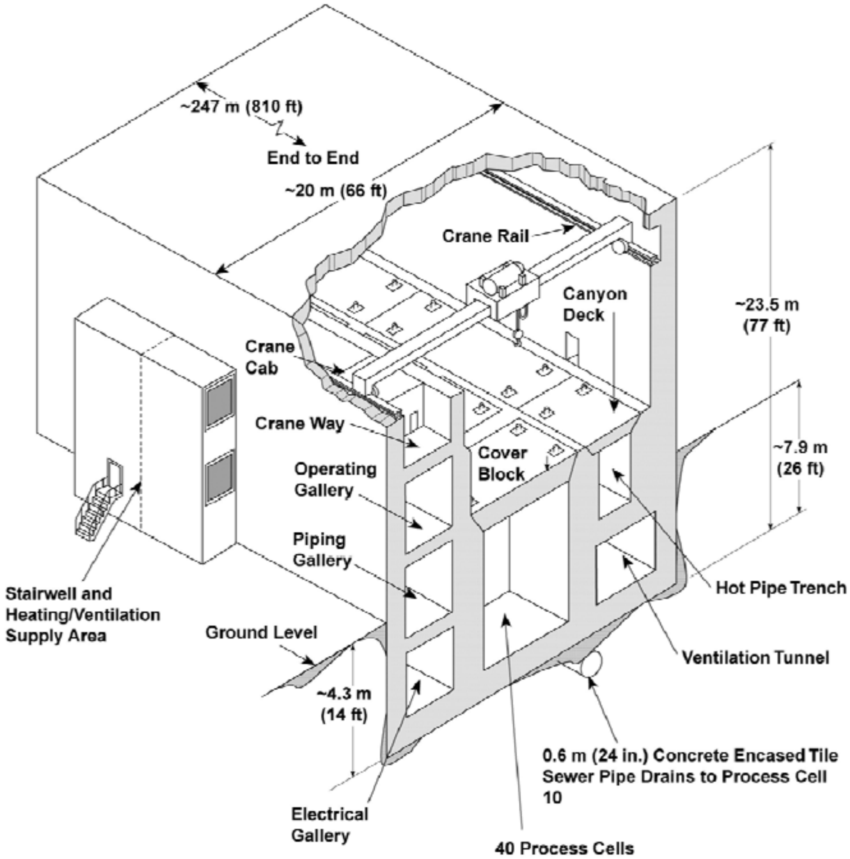

Fig. 2: Cross-section of the 221-U Canyon Facility

INTRODUCTION

The U.S. Department of Energy (DOE) Hanford Site is a 586-square-mile nuclear reservation located in southeastern Washington along the Columbia River. The site is situated north and west of the cities of Richland, Kennewick, and Pasco, an area known as the Tri-Cities. The Hanford Site was established in 1943 during World War II as part of the Manhattan Project to produce plutonium for nuclear weapons, beginning with the “Fat Man” bomb dropped on Nagasaki, Japan on Aug. 9, 1945. Production of nuclear materials for national defense remained the Hanford Site’s primary mission until 1990; today, the site is part of the DOE Environmental Management program and the largest environmental cleanup project in the nation.

The U Plant Area occupies approximately 0.3 square miles within the 200 West Area of the Hanford Site. The U Plant Area includes the 221-U Canyon facility and five ancillary (or support) structures adjacent to the 221-U Facility which have already been demolished, as well as underground pipelines and soil waste sites. The groundwater beneath the U Plant Area has elevated levels of nitrates, technetium-99, and uranium due to past liquid discharges from the U Plant Area facilities and other 200 Area facilities. The centerpiece of the U Plant Area is the 221-

U facility, a large, concrete structure nominally 810 feet long, 66 feet wide and 77 feet high; approximately 30 feet of this height is below grade. The concrete walls and floor range from approximately 3 feet to 9 feet thick. One large room extends the entire length with galleries on the other side of a dividing wall from this room. Covered processing cells reside below the deck in the large room. Because the building has this long, expansive room, it often is referred to as a "canyon building," with the 221-U Facility itself referred to as "U Canyon."

Following the U.S. Environmental Protection Agency's (EPA) Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Record of Decision (ROD) for the final remediation of the U Canyon, CH2M HILL is combining new and existing technologies and techniques to perform a first-of-its-kind canyon demolition and lay the groundwork for the future demolition of four other canyons at the Hanford Site. This paper provides a summary of the five major components of the remedy performed and in progress to accelerate the demolition of the U Canyon complex:

- Size reduction of equipment and clearing of the canyon deck
- Disposition of Tank D-10 Cell 30
- Grouting of void space
- Demolition of the U Canyon building
- Construction of an engineered barrier over the site

HISTORY

The U Plant was constructed in 1944 as one of three original chemical separation plants (along with B Plant and T Plant) to support plutonium production during World War II. The plants were built to extract plutonium from fuel rods irradiated at the Hanford Site's production reactors. Each plant was equipped to use the bismuth-phosphate fuels separation process; however, because T Plant and B Plant met the plutonium production needs at the time, the U Plant was never used for this purpose. Instead, U Plant was used to train B Plant and T Plant operators until 1952, when the building was converted to recover uranium from bismuth-phosphate process wastes.

Bismuth-phosphate process wastes were stored in tank farms in the 200 East and West Areas. From 1952 to 1958, waste slurry was pumped to the U Canyon from single-shell tanks through underground lines. The waste sludge was dissolved in nitric acid (HNO_3) and the uranium was extracted in a kerosene (paraffin hydrocarbon) solvent to extract the uranium from the aqueous phase in counter-current extraction columns. This process left fission products, sulfate, nitrate, and phosphate ions in an aqueous solution while the uranium was partitioned into the organic phase. The uranium was then stripped from the organic solvent with HNO_3. The resulting UNH was converted to UO_3 by calcination at high temperatures in the 224-U Building at the UO_3 Plant.

In 1958, U Canyon was placed in standby mode and has not been used for uranium recovery since that date. From 1958 to 1964, the facility was used to receive, decontaminate, and maintain contaminated equipment from other Hanford Site processing facilities. The equipment was staged on the canyon deck and in process cells, awaiting final disposition.

The adjacent UO_3 facilities continued to be used to convert UNH solution from the nearby PUREX Plant into a solid UO_3 powder. In December 1992, the DOE terminated the UO_3 facilities mission and the last processing was completed in June 1993. When deactivation was complete, the facilities were vacated, emptied of all portable equipment, and locked. All process equipment, instrumentation, and heating, ventilation, and air conditioning (HVAC) systems were shut down and sealed, where appropriate. The deactivation effort left the UO_3 facilities stabilized, requiring a minimal effort for surveillance and maintenance while final disposition decisions were prepared.

In October 2005, the EPA, the DOE, and the Washington State Department of Ecology (Ecology) agreed to disposition the U Canyon under a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* Record of Decision (ROD); EPA et al., 2005, *Record of Decision 221-U Facility [Canyon Disposition Initiative] Hanford Site*, *Washington*). The selected remedy to disposition the U Canyon comprises five major components and was expected to continue for approximately 15 years. In 2008, CH2M HILL was awarded a site remediation contract by DOE that included the preparation of U Canyon for demolition. The receipt of American Recovery and Reinvestment Act (ARRA) funding in 2009 allowed the project schedule to be greatly accelerated; five of the ancillary facilities have since been demolished, and U Canyon itself is now on target to be ready for demolition in 2012.

CLEARING THE DECK

The U Canyon deck was used for storage of hundreds of large pieces of equipment and thousands of smaller items. As part of the effort to clear the deck, an inventory of the equipment was prepared and the equipment mapped to fit into the canyon's process cells and hot pipe trench. The canyon contained 38 accessible process cells that could be used for below-deck storage, with a typical cell volume approximately 180 cubic yards. Most cells already contained some equipment, either original to U Canyon or brought for storage from other facilities. Cell loading (the process of cutting up large pieces of equipment and placing them into the canyon process cells) required leaving the existing in-cell equipment in its current location, with some in-cell repositioning. In cases where equipment hung from racks at the top of a cell, the hanging equipment was moved to a different cell for storage so that the lower level of the cell could be accessed for the placement of equipment.

A space-allocation evaluation and planning effort was performed to confirm that sufficient space was available in the process cells for placement of the various equipment and materials currently located on the canyon deck using existing information. Based on conservative estimates of equipment sizes and space available, the most space-efficient arrangement and location of equipment placement within the process cells was iteratively determined. The largest equipment was given the highest priority for space allocation. The majority of the large components (tanks, centrifuges, condensers, casks, etc.) were identified and mapped to a storage location (receiving cell) based on efficient use of the available cell space.

The placement of smaller equipment that could be more easily located in the remaining spaces was addressed as a second priority. The smaller equipment and the miscellaneous minor components, such as pumps and agitators, were placed in the cells around the large components as space allowed rather than being mapped ahead of time. Further miscellaneous items of insignificant size (i.e., piping, hand rail, scaffold materials, rigging, buckets, hand tools, etc.) existed on the canyon deck that did not warrant mapping to a specific location. The placement flexibility of these small items allowed them to be located in the remaining spaces as needed. As additional information, such as more accurate equipment sizes and space availability, became available the equipment-to-cell mapping was able to be confirmed and refined to maximize efficiencies and use of space.

Figure 3 shows the "before and after" of the repositioning effort.

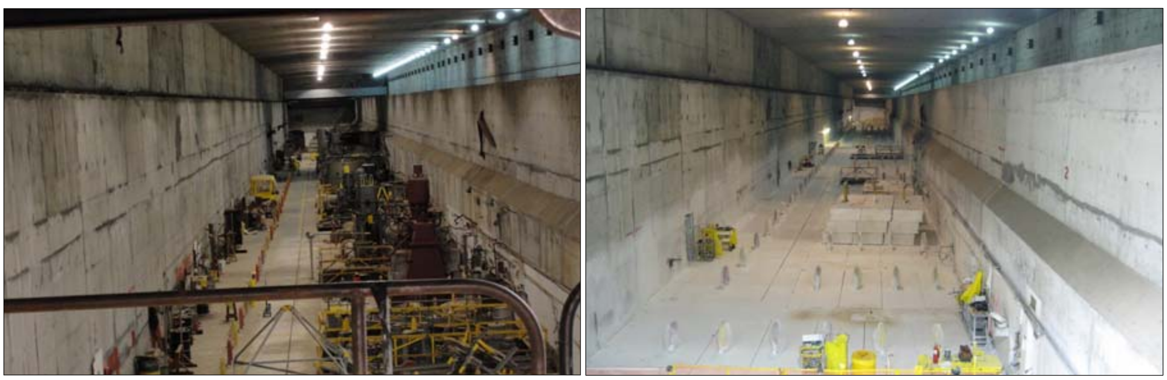

Fig. 3: 221-U Canyon facility interior before and after placement of equipment in cells

REMOVING TANK D-10

The existing 221-U Canyon Facility ROD has the following requirement:

> *Residual materials that would have transuranic isotope concentrations greater than 100 nCi/g after stabilization (such as liquid and sludge identified in a tank in process Cell 30) will be removed and dispositioned prior to stabilization in accordance with an approved remedial design/remedial action work plan.*

Cell 30 has an existing tank (Tank D-10) that exceeds the transuranic (TRU) isotope concentration and must be remediated separately from the U Canyon. The initial plan for Tank D-10 was to absorb the plutonium-rich solution from the tank and transfer that liquid into containers for storage at the Hanford Central Waste Storage Complex. The residual materials in the tank would then be stabilized with grout, with the stabilized waste form expected to contain less than the allowable 100 nCi/gram of TRU isotopes. However, supplemental characterization resulted in the following determination:

- Tank D-10 contained more than 1,800 L of remote-handled TRU mixed waste, rather than the 757 L previously estimated.
- The waste in the tank was predominantly solid, rather than liquid as previously estimated.
- Both the solids and liquids within the tank contained concentrations of TRU isotopes in excess of the 100 nCi/ gram limit for TRU waste.

Based on this characterization, the remedy initially planned for Tank D-10 would not have achieve the reduced radionuclide content necessary to be allowed to remain in U Canyon. Plans were therefore changed to remove the entire tank from the canyon by absorbing the liquids in place, sealing the tank openings, and removing the tank in a shielded container for storage elsewhere on the Hanford Site. This work is not required to be completed prior to the start of grouting the process cells, but will need to be complete before grouting can be finished.

PREPARATION FOR GROUTING & HAZARDOUS MATERIAL REMOVAL

Several activities are necessary to allow the grouting and eventual demolition of U Canyon. These include:

- Hazardous material and waste removal
- Removal of energy sources (Cold and Dark)
- Performing radiological surveys of the internal structure
- Decontamination and fixing remaining contamination in place

Hazardous material removal includes draining and removing oils from facility infrastructure equipment (motors, gear boxes, elevator drives, door closers, and the overhead crane), abatement of asbestos in areas to be demolished, and disposing of waste in an approved manner.

Removing the energy sources (known as taking the structure ‘Cold and Dark’) will occur in phases. In the first phase, necessary to allow the grouting of the facility, all normal energy sources have been disconnected and temporary power has been provided to the canyon’s main exhaust fan, the overhead crane and to temporary lighting and heaters for “clean rooms,” tool cribs, and other still-active work areas. This has entailed routing new exposed temporary cables and systems for all power requirements in the building prior to starting to pump grout. Once the facility is grouted, the exhaust fan will no longer have a purpose, and the temporary power will be disconnected prior to demolition.

Concurrently with the hazardous material removal, canyon surfaces are being surveyed for contamination, decontamination performed, and fixative applied to canyon surfaces. This process is ongoing, with the canyon deck complete and the walls and ceiling awaiting completion of below-deck grouting. The results of these surveys will be used to perform air dispersion modeling to allow the eventual explosive demolition of the canyon. Once contamination levels throughout the canyon have been reduced to the levels required and further fixative applied if necessary, the canyon will be in final condition to allow demolition.

BELOW-DECK GROUTING

Per the 221-U Canyon Facility ROD,

> *Cementitious grout will be pumped into the galleries, cell drain header, process cells, and tanks containing residual materials to the maximum extent practical, to minimize the potential for void spaces and to reduce the mobility, solubility, and/or toxicity of the grouted waste.*

A grout mix has been developed to fill void spaces within the U Canyon. The primary purpose of void space grouting is to create a monolith of the physical canyon structure and the grouted interior. This monolith then provides a stable base for the construction of an engineered barrier and a nearly impenetrable barrier to water and contaminant migration.
The development of this grout was based on meeting the following set of performance criteria:

- Minimum Compressive Strength – 1,500 lbs/in.^{2} at 28 days
- Minimum Flow Distance – 80 feet
- Maximum Heat of Hydration – not greater than 13°F for 100 lb of cement

These performance criteria were developed to create a flowable, structural grout with good compressive strength capable of filling void spaces within the canyon to the maximum extent practicable. Void space grouting of U Canyon will begin with grouting a test cell (Cell 10). Grouting will then proceed with the most contaminated areas. After Cell 10 is grouted, grouting the remaining void spaces will proceed in the following sequence:

- Cell drain header and process sewer
- Process cells, including the buoyant vessels
- Hot pipe trench
- Electrical and piping galleries
- Ventilation tunnel, vent duct, sand filter cap, and vent ducts to the exhaust stack

The primary goals of sequencing the void space grouting in this manner are to grout the most contaminated areas first, and then grout the process waste system to prevent any future releases from the canyon. In addition, this sequence allows the canyon ventilation system to remain operational through most of the course of the grouting process, thus reducing the potential for airborne contamination and enhancing worker protection during the grouting operations.
An onsite batch plant will be used to produce grout to fill the void spaces within the canyon. The batch plant location is directly north of the canyon and provides easy access to the canyon and necessary onsite resources needed to support grout production.

The design for delivery of grout to the canyon established 12 specific pumping locations along the canyon and near the exterior ventilation system. The design capacity for pumping and delivery of grout to the canyon is based on the operation of two pumps with a minimum 80 cubic yards-per-hour capacity, and the piping necessary to deliver that quantity along the canyon exterior and through the canyon area to the cells, galleries, and other grout placement locations.

Table I lists grouting locations and quantities projected for grouting activities.

Table I. Grout Quantities by Location

Location	Quantity (cubic yards)
Drain Header	110
Process Sewer	93
Buoyant Vessels	670
Process Cells	6,084
Hot Pipe Trench	1,029
Electrical Gallery	4,497
Piping Gallery	4,314
Ventilation Tunnel	2,940
Vent Ducts to Stack	581
Total	**20,318**

READY FOR DEMOLITION

When the preceding actions are complete, the canyon will be ready for demolition. Equipment within the building will have been dispositioned, void spaces filled with grout, contamination on exposed surfaces inside the canyon addressed, and the surrounding area prepared to support canyon demolition. Waste generated during building preparation for demolition will have been dispositioned at approved facilities. The following describes the next phase of actions required to partially demolish the U Canyon.

An engineering study was performed to examine the technical, environmental, regulatory, financial, and nuclear safety feasibility of demolishing the canyon down to approximately the deck level. The basis for this study included engineering investigations, preliminary evaluations of alternatives, and the results of an informal value engineering session. The study provided recommendations regarding demolition alternatives and final facility configurations of the demolished canyon shell, concluding that the facility should be demolished to the deck elevation. Given the sheer size of U Canyon and the thickness of its walls, the safest method to demolish the canyon is to use explosives. Explosive demolition of similarly robust facilities has been successfully been used on the TAN “Hot Shop” at the DOE’s INL site in Idaho, and on the B886 “Crit Lab” at the RFETS site near Denver, Colorado. The use of explosives minimizes worker exposure to hands-on demolition hazards and increases efficiencies of both cost and schedule.

Explosives will first be used to open arches along the length of the canyon. The arch rubble will be removed and then the roof and remaining wall columns will be detonated to bring the structure to the deck level. The interior crane wall and operating gallery wall will be demolished prior to or at the same time as the arches are cut. All the rubble can be consolidated on the deck and surrounding soil to provide a firm foundation for the engineered barrier. This selected final structure configuration, with its final deck elevation, not only reduces the hazards to workers but results in moderate capping costs compared to other final structure configurations. The final step will be the construction of an engineered barrier to place U Canyon’s remains in a safe configuration for the foreseeable future.

ENGINEERED BARRIER

The engineered barrier for U Canyon will consist of three parts: engineered fill, engineered barrier (the functional portion of the barrier), and erosion protection. In U Canyon’s case, the engineered barrier planned is unique in that the top of the barrier is approximately 35 feet above the surrounding grade.

The performance criteria developed for the engineered barrier design are as follows:

- Prevents recharge rates greater than 3.2 mm/yr long-term average in order to mitigate, or eliminate, the potential for contaminants to migrate to groundwater

- Provides the required containment during a minimum 500-year life
- Constructed with the minimum potential impact to worker safety and the environment, using established/proven technologies also responsive to cost and schedule concerns

Engineered Fill

The engineered fill will be clean, compacted, granular material that will be placed in lifts. Borrow materials for the engineered barrier will be taken from approved areas of the Hanford Site including recycled concrete from other demolition projects on site. The approximate extent of the engineered fill and engineered barrier is shown in Figure 4. Final design of the engineered fill will determine the compaction requirements and the material specifications. Where fill material consists mostly of rubble or very large particles, finer grained fill soils may gradually settle into the open pores or spaces of the coarser material, which eventually may cause localized subsidence. To counteract subsidence, graded filters may be required. These filters likely will consist of commercially available gravels, with the gradation selected on the ability to bridge the openings in the previously placed material.

Engineered Infiltration Barrier

The engineered barrier will be designed to control potential contaminant migration by preventing water infiltration, as well as minimize potential human and biotic exposures due to biotic and unintentional human intrusion. To accomplish this, the engineered barrier, in combination with the remaining grouted, substantial concrete substructure, will effectively break the pathway for direct contact with contaminants. The upper portion of the barrier will consist primarily of a fine soil, such as a silt or silt-loam, which will be specifically selected for its ability to hold and store infiltrating water for eventual evaporation and plant transpiration. The lower portion of the barrier will consist of engineered or grading fill that will form the basic shape/slope of the barrier, provide a stable subgrade for constructing the overlying layers, and provide the balance of the barrier thickness. The barrier will be vegetated to control soil erosion and promote transpiration. The total volume of material that will be required for the engineered barrier will be determined during final design.

Erosion Protection

The top of the engineered barrier will be sloped at a nominal 2 percent; the top layer will be vegetated and likely will consist of pea gravel and mix. Therefore, once vegetation is established, erosion from precipitation and wind should not be a concern. To reduce the volume of the engineered fill while providing stability during a seismic event, it is likely that a 3H:1V side slope will be selected for the engineered fill. This slope will require placement of a basalt riprap-type layer for erosion protection. The erosion protection layer may include gravel and sand filter layers to carry the runoff safely to the outer toe of the engineered barrier.

Revegetation

The excavations from demolition activities will be backfilled, and fill contours will match adjacent contours. Areas disturbed by demolition activities will be prepared for surface restoration. As required for industrial land use in Hanford's 200 Areas, the majority of restoration will consist of the application of an approved native seed mixture with input from various interested local tribal nations.

CONCLUSION

U Canyon is the first of the canyon-like facilities across the DOE complex to be prepared for the demolition outlined in this paper. The agreements, methods used, and lessons learned will become the model for the rest of the canyon demolition projects both at Hanford and across the DOE complex. Receipt of American Reinvestment and Recovery Act funds has allowed CH2M HILL to greatly accelerate demolition preparations to put the facility in a safe non-operating condition, and bring U Canyon to "demo ready" by the end of Fiscal Year 2011. The final demolition and construction of the engineered barrier may still be dependent on future funding received at Hanford, but this ongoing project is well ahead of the Regulatory schedule and is being accomplished both efficiently and safely by CH2M HILL Plateau Remediation Company's workforce at the Hanford Site.

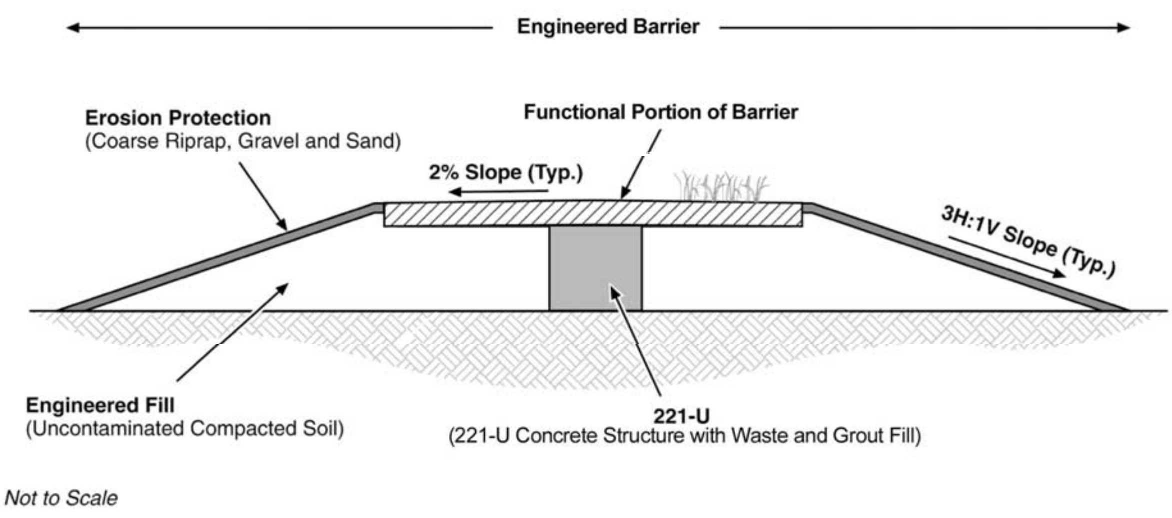

Fig. 4: Diagram of the engineered cap planned for the U Canyon demolition.