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300-296 Soil Remediation Project
Developing Innovative Solutions to Overcome Design Challenges – 16229

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ABSTRACT

The 324 Building is a non-reactor, Hazard Category 2, Nuclear Facility located in the 300 Area of the U.S. Department of Energy (DOE) Hanford Site, located near Richland, Washington. The building is undergoing deactivation, decommissioning, decontamination, and demolition by Washington Closure Hanford (WCH) under the River Corridor Closure Contract. During the Cold War Era, the facility was used for chemical and radionuclide processing associated with nuclear weapons production.

Historical records [1] indicate that in October 1986, approximately 516 L of a concentrated liquid waste stream containing cesium-137 and strontium-90 was spilled onto the floor of B-Cell. B-Cell is located in the Radiochemical Engineering Complex (REC) of the 324 Building. It is estimated that this spill contained approximately 1.3 million curies of radioactivity. Some fraction of the spill was recovered; however, an unknown quantity was released into the soil beneath the 324 Building through an undetected breach in the B-Cell floor sump. Unknown quantities of water were used after the spill to wash items contained in B-Cell. When B-Cell was taken out of service, wastes being removed from B-Cell were placed in Grout Containers (GCs) and stabilized using a particulate grout. In the course of grouting activities, grout was spilled on the floor of B-Cell, eventually filling the sump.

The primary scope of this project is to design, test, and implement a process capable of removing and isolating contaminated soil below B-Cell. This remediation effort has been divided into two removal zones identified as the primary and secondary removal zones.

Based on current assumptions and estimates, the primary phase of this cleanup effort will remove roughly 156.45 m^3 of highly contaminated materials. B-Cell debris, particulate grout, and the floor slab and liner comprise about 21.24 m^3 of the total. The remaining 135.21 m^3 will be contaminated soil. All of this material must be disposed of within the existing 324 Facility or packaged for disposal at the Hanford site.

The objective of this project is to remove the B-Cell floor and highly contaminated underlying soils from beneath B-Cell using remote

equipment to reduce the radiation levels and allow open-air excavation for the remaining contaminated soil.

The challenges and subsequent technological solutions encountered from the Conceptual Design phase to the 100% Design Issued For Fabrication/Issued For Construction (IFF/IFC) consisted in part of the following:

Design an efficient remote cleanup strategy for highly contaminated Low Level Waste (LLW) given the unknowns.
Maintain contamination control down to 18 feet below B-Cell in a highly radioactive environment (12,870 R/Hr Cs-137 & Sr-90).
Perform facility upgrades to enable remediation process implementation while maintaining integrity of pre-existing facility structure and license.
Designing first-of-a-kind remote equipment for use in high radiation areas.
Developing first-of-a-kind operations sequences for remote equipment while minimizing usage of original facility equipment (i.e. cranes, manipulators, etc.).
Conducting time-motion studies of operations sequences to maximize efficiency while keeping dose As Low As Reasonably Achievable (ALARA) in a high dose environment.
Construction of a full scale mockup to conduct performance testing in a clean environment and train the work force to operate the equipment.
Overcoming scope, budget and schedule constraints associated with a fast-track DOE project.

INTRODUCTION

On January 20, 2014 the AREVA Federal Services (AFS) team consisting of AFS, Federal Engineers & Constructors (FE&C), Remote Systems Engineering (RSE), Kurion, and Dade Moeller were awarded the contract by WCH to remediate the highly contaminated soil beneath the B-Cell floor of the 324 Facility. The Project was awarded in a phased approach which included:

- Phase I - Assessment of 324 Building mechanical/electrical system and Conceptual Design Report
- Phase II - Engineering Design 30%, 60%, 90%, 100% IFF/IFC for remote equipment and the design and construction of a full scale mockup facility
- Phase III – (optional) Procurement & fabrication of equipment and Qualification and Testing in the mockup facility
- Phase IV – (optional) Installation, Operations and Demobilization of 324 activities

The primary objective of this project is to design, fabricate, test, and deploy remote equipment capable of removing and isolating highly contaminated material and soil within and below B-Cell to reduce the radiation levels and allow open-air excavation for remediating the remaining contaminated soil.

The objective also included the design and construction of a full scale mockup facility where performance testing of the remote equipment in a clean environment could be performed as well as training the work force performing the work activities.

Based on current assumptions and estimates, the primary phase of this cleanup effort will remove roughly 156.45 m^3 of highly contaminated materials. B-Cell debris, particulate grout, and the floor slab and liner comprise about 21.24 m^3 of the total. The remaining 135.21 m^3 will be contaminated soil. All of this material must be disposed of within the existing 324 Facility or packaged for disposal at the Hanford site due to the extremely high radiation exposure potential (~12,870 R/hr).

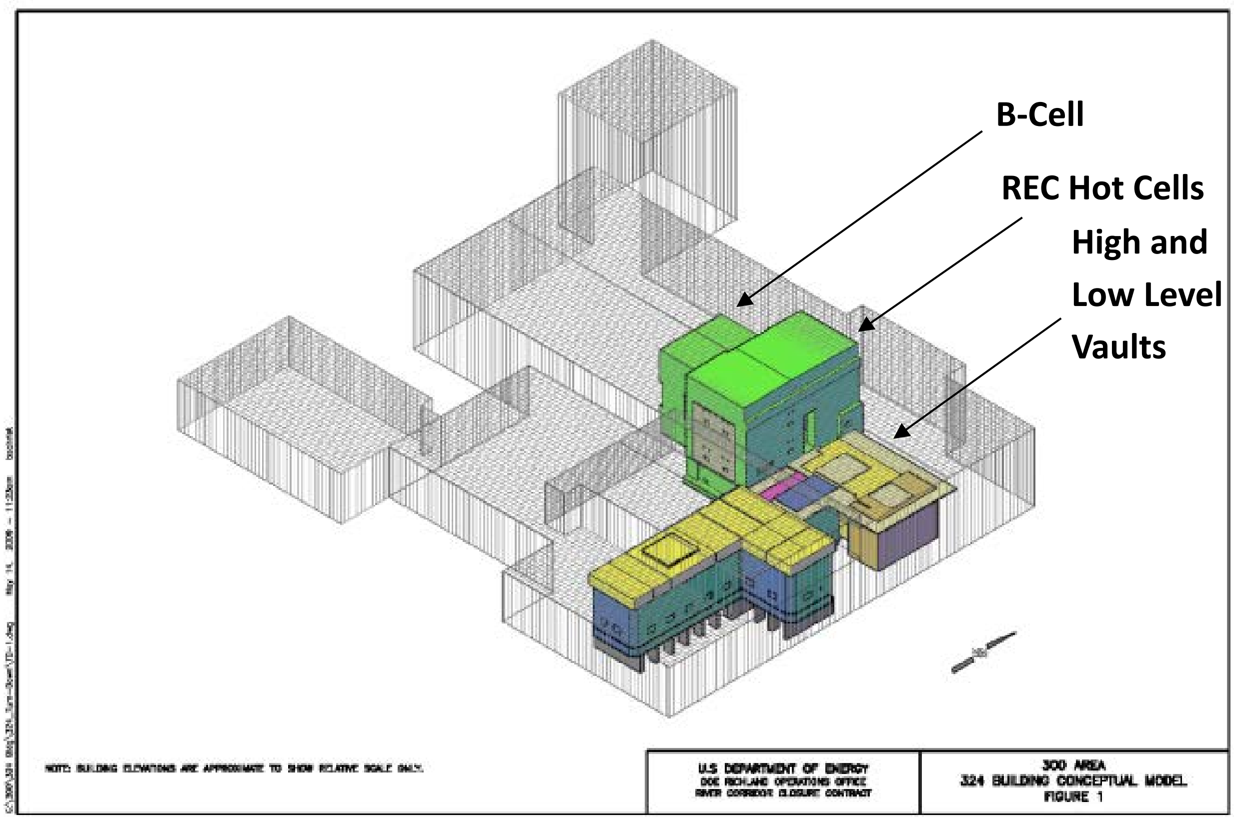

Fig. 1, Overview of REC Hot Cells inside 324 Building

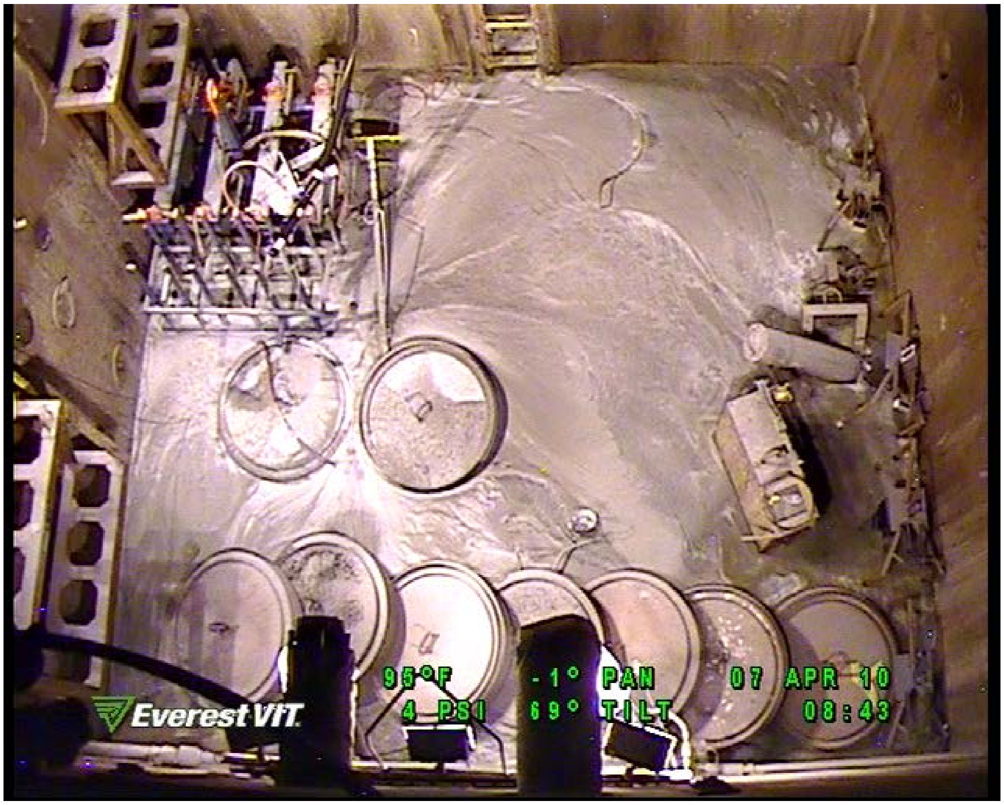

Fig. 2, B-Cell Floor & Equipment Immobilized in 15.24 cm of Grout

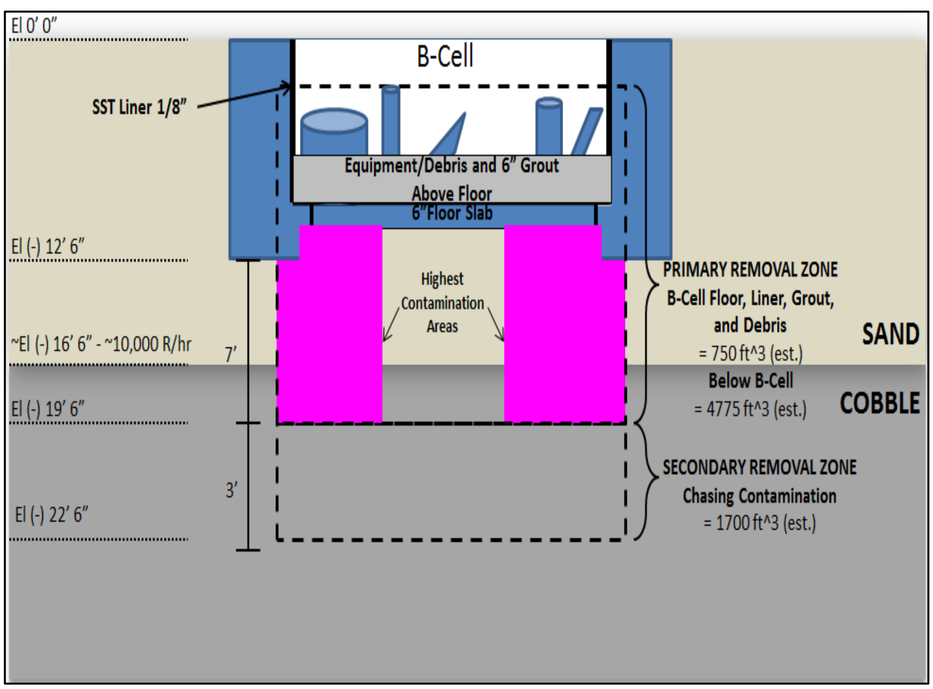

Fig. 3, Primary and Secondary Contamination Area Beneath B-Cell

Design Challenges and Innovative Solutions

The major challenges and subsequent innovative solutions encountered from the Conceptual Design phase to the 90% and ultimately 100% Design IFF/IFC consisted, in part, of the following methods and results:

- Designing an efficient remote cleanup strategy for highly contaminated LLW given the unknowns.
    - One of the uncertainties was the potential radiation exposure. The initial exposure potential measurement taken in 2011[2] indicated the peak reading of 10,000 R/Hr. A second Geoprobe®[1] measurement was taken in September of 2014 nine months after the design efforts had begun. The result was an increase to 12,870 R/Hr. on contact. Equipment had to be tested and evaluated to ensure it was radiation resistant to a higher level than initially planned at the conceptual stage moving through the 60% and 90% design stages.
- Perform facility upgrades to enable remediation process implementation while maintaining integrity of pre-existing facility structure and license.
    - To perform the facility upgrades enabling the technical remediation process implementation, the project used a team approach. The team engaged the field operations organizations from the inception of the project in order to integrate the construction and operations issues and concerns into the planning, engineering, and procurement activities. Integrating this into the design effort optimized the work package planning and early identification of hazards and operational sequencing. This input was verified during the review of drawings and specifications prior to the issuance for construction.
    - A large grout dam had to be designed to block and seal the A-Cell door frame during the grouting process. The A-Cell dam will be installed using remote operations. This will allow the waste to be lifted over the dam to load the cell with waste.
- Designing first-of-a-kind remote equipment for use in extremely high radiation areas was the key to ensuring safe operations during the remediation process. The risk of contamination exposure to the workers, the environment and the public was very high with radiological exposure rates of 12,870 R/hr. on contact. Using remote equipment was the only viable option. To ensure reliability of the equipment, Proof-of-Principal (PoP) testing was performed on the equipment and grout mixture(s) to further demonstrate that the equipment and grout mixture(s) would perform as

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[1] Geoprobe is a trademark of Keir, Inc., Salina, Kansas

designed. The 60% and 90% design stages demonstrated and verified the following:

- o The grout mix for stabilizing the soil, ensuring contamination control (no dust) and filling the void space in A-, C- and D-Cells worked as designed.
- o The upper and lower Remote Excavator Arms (REAs) and anchor plate(s) were optimized and validated due to early issues with the bottom rotating mechanism.
- o The waste sacks as initially designed were inadequate, especially for the larger debris to be removed. Waste bins had to be designed for efficient loading/unloading out of B-Cell, and transfer through the REC.
- o The waste transfer barrier had to be redesigned to facilitate efficient waste bin movement and operational requirements associated with the cell door position.
- o Floor cutting saw mounted to a lifting frame for access in and out of B-cell was tested to ensure it could cut through the stainless steel liner, concrete and rebar comprising the cell floor. The remote design required a saw blade change which was to be optimized through testing.
- o A Remote Operated Impact Device was designed during the 60% phase to facilitate removal of set screws in the floor hatch between C and D-Cell.
- o A Seal Breaker Lifting Device was designed during the 60% phase to lift the hatch.

- Structural Stabilization for the 324 Building

  - o The primary building support feature, a spreader beam, had to be re-designed due to increased soil bearing pressures and the potential for soil settlement. A new spreader beam with caisson footings is now designed including tension rod assemblies within the bottom section of the B-Cell north and south walls.

  - o REC A-Cell and C-Cell Floor Capacities analysis performed during the 60% design phase concluded that floor-re-enforcements as initially designed in A and C-Cells would be difficult, therefore a new approach was initiated to fill the voids in the duct crawl space below the existing cell floors with cementitious grout to provide a direct load path to the soil below. This approach significantly reduced the cell floor displacement. It also provides additional support to the east REC foundation wall footings to further reduce REC settlement.

- Conducting time-motion studies of operational sequences to maximize efficiency while keeping dose As Low As Reasonably Achievable “(ALARA)” in a high dose environment.

  - Sequenced operations to remove the high dose debris and soils, transfer the debris and soil, and place it in the other REC hot cells was optimized through re-design and placement of the waste bins and transfer barrier. The airlock and B-Cell debris would have to be removed first before B-Cell operations could be performed.

- Construction of a full scale mockup to conduct performance testing in a clean environment and train the workforce that will use the equipment to perform the operations.

  - Construction of the full scale mockup was worked in parallel with the design phases and was completed as scheduled. Initially due to permitting delays, the construction activities were started behind schedule. The work activities were conducted on ten hour work days six days a week as part of the recovery plan to meet schedule.

  - Equipment Qualification and Testing in Phase III and Operations in Phase IV were placed on hold by DOE and the project put into a closeout phase due to insufficient funding allocation and priority.

CONCLUSION

The challenges outlined above put the project schedule at risk and posed a potential delay for completion by approximately four months. Working in collaboration with the project team and the client, the methods described above resulted in the following successful deliverables:

- Delivery of a useable design ready to be implemented in the field.
- A full scale mockup facility ready for remote equipment installation to conduct performance testing and workforce training.
- Designed facility upgrades to enable remediation process implementation while maintaining integrity of pre-existing facility structure and safety basis.
- Designed safe and reliable first-of-a-kind remote equipment to protect the workers, environment, and the public from high radiological exposure during the remediation operations.

The completed Design Package consisted of:

- 702 Drawings
- 31 Design and PoP Reports
- 30 Calculations
- 23 Safety Classification Forms
- 5 Specifications
- 2 Design Requirements Documents

REFERENCES

1. KUR-1782F-RPT-002, 300-296 Soil Remediation Project Phase I & II Conceptual Design Report, November 5, 2014, Kurion Inc.

2. KUR-1782F-RPT-001, 300-296 Soil Remediation Project Phase I & II Assessment Report, July 2, 2014, Kurion Inc.