In Situ Decommissioning Lessons Learned – 14042

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ABSTRACT

In situ decommissioning (ISD) is the permanent entombment¹ of a contaminated facility. By the end of 2011, the U.S. Department of Energy's Office of Environmental Management had completed first-of-akind, ISD projects for major contaminated facilities at three of its largest sites. Considering the uniqueness of these projects, their complexity, and the challenges faced along with the realization that it would be several years before new ISD projects would be conducted, it was important to capture the experience gained and lesson learned for the benefit of future project managers, planners, technical staff, and field personnel. This was accomplished in a comprehensive report that is summarized in this paper.

INTRODUCTION

Background

In 2008 EM published the *DOE Office of Environmental Management (EM) Strategy and Experience for In Situ Decommissioning* (Reference 1). This report served to formally define and endorse the In Situ Decommissioning (ISD) concept as an acceptable method of decommissioning; in effect it was a policy statement. It summarized the planning and environmental approval efforts for ISD that had been accomplished as of 2008. However, at that time none of these projects had been funded to conduct final decommissioning.

In 2009 the American Reinvestment and Recovery Act (ARRA) provided the opportunity for the acceleration of several (ISD) projects across the DOE complex. The projects included facilities at INL, the Savannah River Site (SRS), and Hanford. These projects were completed in 2011.

In 2013 EM published a report, *DOE EM Project Experience & Lessons Learned for In Situ Decommissioning* (Reference 2). This report (called the "experience report" herein) described the ISD projects conducted with ARRA funding, their challenges, lessons learned, and examples of management, engineering, and field methods used. The information for this report was based on interviews and information of the projects conducted at Hanford, the Idaho National Laboratory, and the Savannah River site. This paper presents highlights of that report; the authors of that report are the same as this paper. The authors are privileged to be assigned the rewarding task of recording the ISD project experience resulting from the performance of the field teams at Hanford, Idaho National Laboratory, and the Savannah River site. The performance of those who conducted these first of a kind, challenging projects within budget and schedule was truly outstanding.

Purpose

In situ decommissioning of EM's facilities faces challenges typical of new construction projects involving placement of massive quantities of grout, which is made difficult by the presence of contamination and radiation, constrained by the complex configuration of the types of facilities, and complicated by conditions resulting from having not been occupied for an extended period of time. Further, many of the

¹ In "entombment," facilities containing radioactive contaminants are permanently encased within in a structurally stable material, such as grout, and appropriately maintained and monitored until the radioactivity decays to a level permitting restricted release of the property.

challenges faced for contaminated demolition projects are also present; characterization for planning is one such example.

These projects were first of a kind and unique. There were many insights gained, understanding of what worked well, disappointment at what did not, engineering and management tools developed, and operational lessons as how to conduct the field work. As current and projected budgets for the EM program indicate reduced and flat funding profiles for the foreseeable future, the potential exists for this institutional knowledge to be lost as the ramp-down of project staffing commences with the cessation of ARRA.

The purpose of the experience report was to capture the considerable technical knowhow gained. EM's Office of Deactivation & Decommissioning and Facility Engineering tasked the report creation to record the experience while still readily accessible. It provides starting point for DOE's future federal project directors along with other federal and contractor managers and staff so they may effectively and efficiently plan and implement subsequent ISD projects.

Reporting lessons learned with the specific projects where they occurred provides a useful context for others to use them Selected from the experience report are some lesson highlights described below.

COMPARISONS AMONG ISD PROJECTS

ISD projects addressed in the experience report share similarities and have differences. In general, their scope has been for two types of facilities; namely, nuclear reactors and those for processing nuclear reactor fuel. The projects were:

- Two large production reactors (P and R) and their ancillary facilities at SRS
- The below grade portion of several small reactors facilities at INL and one at SRS
- Fuel processing facilities at INL (Buildings 601/640)
- The lower structure of the U Canyon at Hanford

One observation drawn from these projects regards several small ISD projects. They are different from the P and R reactor projects in that the reactor vessel and other components within the structures were removed and disposed of in the local CERCLA or low level waste disposal cell. The technical difficulty, potential personnel exposure, and cost for these projects were sufficiently low such that leaving the more significant source (the reactor vessel) was not warranted. Another driver for removing the significant sources of contamination is that these smaller facilities were all relatively isolated by distance from a much large closure area where the government can focus its management of ongoing institutional control. At these projects the major sources of contamination was removed, leaving below grade small amounts of radioactivity with reasonably short half lives that will decay to inconsequential levels in a few hundred years.

Among the larger projects, there are significant differences at the three sites for the degree of structure that remains above ground. The differences are related to the initial height and robustness of above ground portions of the facilities. At INL, the structural design of the above-grade portions of the buildings is steel frame construction. It is not expected that such facilities would serve as good confinement over the long term. At INL, these were demolished to grade, with the exception of a small section of heavily shielded concrete process cells that were highly radioactive, with a vertical protrusion of about 18 ft (5.5 m) above grade. An earthen cover, primarily gravel, was placed over this portion; the entombed facilities will eventually become part of a much larger area closure with a permanent cap. See Figures 1 and 2.

At both SRS and Hanford, a substantial part of the structure remains above the site ground level. The Pand R-Reactor buildings at SRS and part of the U Canyon at Hanford are very robust, thick walled, reinforced concrete structures.

At the P- and R- reactors the above grade portion of the reactor building will remain empty, projecting well above the surrounding area. In this case, the primary radiological sources are concentrated with the reactor vessel, which is below ground and has been grouted in place. A permanent cap has been installed above the vessel that is structurally designed to protect the vessel monolith from damage that might be caused by material falling from inside the buildings. The reactor buildings have been sealed and selected roofs have been modified with sloped concrete caps to prevent water intrusion. See Figure 3.

In contrast, the remaining above ground portion of the U Canyon will be filled with grout and a permanent cap will be placed over the entire area. The primary sources of contamination at the U Canyon is equipment that has been grouted within the below grade process cells. Grouting of the remaining part of the canyon is planned to be conducted as a future project. See Figures 4 and 5

Another difference of interest among the projects is that at U Canyon and the SRS reactors, equipment and materials associated with the facility mission that were outside of the major structure were moved inside to be grouted within the structure. This was not done at INL simply because there was not a substantial amount of such items. If anything, the cleanout of Buildings 601/640 at INL was considerably more substantial than at the other projects because of the amount of RCRA regulated hazardous materials that had to be removed.

The overall lesson from comparing these projects is that there can be substantial differences in the final configurations among ISD projects. These differences are driven by, but not limited to, original construction and configuration, the site characteristics, and proximity to other large closure projects (as described above for the small reactor projects). Ultimately, such decisions are driven by the CERCLA and RCRA process as applied to the project. Those planning ISD projects at other sites would benefit from reviewing the Engineering Analysis/Cost Evaluations and Action Memoranda for the projects described in this report to gain an awareness of the alternatives considered for each project.



Figure 1 – Isometric View of CPP-601



Figure 2 – CPP-601/640 Before and After ISD



Figure 3 – P-Reactor Area Before and After ISD



Figure 4 – U Canyon



Figure 5 -- U Canyon ISD Concept Engineered Barrier Components

CONTRACTING AND SUBCONTRACTOR MANAGEMENT

Companies that supply and install large quantities of grout and concrete are accustomed to major new build projects. In contrast, providing those services to entomb an existing radiological contaminated facility is out of the ordinary. The overall lesson is to think very carefully as to how much work to subcontract versus self performance by the prime contractor. At SRS it was decided to self perform in those areas where radiological contamination and direct radiation were prevalent and to maximize subcontracting for other work.

Other than that, interfaces between self-performed work and subcontracted work should be minimized. For example, having two separate contracts, one for batch plant operation and a second for supply of raw materials for grout production resulted in the prime contractor being responsible for that interface. It would have been better to make the grouting subcontractor responsible for the batch plant operation and supply of raw materials for grout production. This ensures the production of grout is maintained at a level to support the placement schedule.

The technical interface with subcontractors is also very important. In one case of sealing penetrations within the building prior to grouting, the schedule was impacted because insufficient specificity was provided to the subcontractor for custom fixtures needed to seal penetrations. It was concluded that more details should be provided on design sketches for penetration sealing, that all penetrations should be reviewed for needed variations in fixtures, and that project engineers should work with subcontractors for selection and/or design of devices for sealing of penetrations prior to grouting.

PROJECT ENGINEERING AND TECHNICAL PLANNING

Understanding in advance the important engineering and technical challenges is an important aspect of any decommissioning project. The following describe some specific to the ISD projects in this report.

Characterization Technology

Characterization of the ISD facilities can be difficult due to nature and extent of contamination, with many areas inaccessible due to physical constraints and/or safety and health concerns. Remote access technologies were important for enabling the collection of needed data; characterization of these facilities would not have been accomplished to the same degree without them.

Engineering Studies

The U Canyon experience showed that conducting the engineering studies well in advance of the actual need was beneficial in determining the best path forward. Six major studies were conducted; two that were especially important for support of the field work are as follows:

- Within U Canyon, many of the systems and equipment (such as ventilation, the canyon crane, railroad tunnel, electric power, and others) that were necessary to support the ISD preparation activities had been out of service and not maintained for a lengthy period of time. Due to the age of these systems, the availability of replacement parts was a concern. Engineers assessed the options for each function and recommend a path forward that minimized potential for schedule impacts. In cases for which refurbishment/reactivation of existing systems was chosen, essential components were identified and purchased in advance; provisions for back-up capability (i.e., mobile cranes, localized ventilation units) were included in the project planning.
- After its active mission, U Canyon served as a staging and storage area for a wide assortment of equipment from other canyon facilities. The majority of this material was placed on the canyon deck; items with higher radiation levels were randomly placed inside the process cells. The sizes and weights of this material range from very small (lbs) to very large (tons). Concern was raised as to whether this material could be placed in the process cells, which also contained original process equipment as well as the higher radiation level materials; and whether significant size reduction efforts would be required. By conducting a comprehensive engineering study utilizing still photographs and video footage, engineers were able to evaluate the sizes of the legacy items compared with the available space within the process cells to determine the exact placement location and orientation for each piece. They were able to ensure that all of the material stored on the canyon deck could be placed in the process cells. The upfront planning determined that size reduction was not required, and it eliminated the need for multiple handling of equipment and minimized the number of times the process cell cover block had to be removed. The results of the study were used in work planning and execution.

Understanding Structural Robustness

Demolition of the P and R Disassembly Basin buildings was very difficult because of the robustness of the structure and significant amounts of reinforcing steel. Even with larger equipment than originally planned, demolition took almost twice as long to complete than estimated. In hindsight, the above grade structures could have been grouted in place to function as closure caps for the basins. To do this, all the external openings in the above-grade structure would have been formed up to allow filling the entire above-grade structure with concrete resulting in a robust monolith atop the grout-filled basin. As it was, separate concrete caps had to be placed above the grouted basins. As a result, it has been recommended that the basin buildings at other reactors to be entombed be considered for the revised approach.

This observation is similar to what has been learned at other demolition projects; that investigation of the design and actual construction of reinforced concrete structures is an important part of technical planning. In addressing this, the first step is to retrieve design drawings. However, experience has shown that updating design drawings to as-built status often does not occur or may be unreliable for design features such as rebar size and placement. When understanding the structural robustness is important to planning and decisions, additional measures for characterization should be conducted to define the internal structure using methods such as core bore sampling, acoustic imaging, and radar.

Water and Liquids

Water management plans for radiological demolition areas must be in place early to ensure rain water and water used for dust suppression is contained and managed within the radiation boundaries. Plans for disposition of the water should also be in place early in the project to ensure proper disposition pathways. Sequencing of work on the structure should carefully consider the timing of closing roof drains and sewers to minimize water management issues.

Another lesson is that regardless of whether liquid piping systems are recorded to have been tapped and drained, piping may not be empty of liquid. This may be because complete draining can be difficult

without destructively cutting into the system; which is not normally done during deactivation. Where critical to safety or grouting operations, overhead piping system should be assumed to contain residual liquids as part of work planning.

Grouting Impact on Ventilation

Proper ventilation of equipment (i.e., tanks, vessels, and piping) and general areas of facilities is necessary to ensure complete filling of these areas with grout. As the grout is being introduced into these areas, the air that is being displaced must have an exit pathway. Provisions for controlling the spread of contamination while the displaced air is exhausted are often required; for example with placement of filtered vents.

Visualization Planning Tools

Planning and work management can benefit from visualization methods and hardware. Three examples are:

- A graphical method of display at the U Canyon displayed the status of grout lifts throughout the facility (which is enormous).
- Sacrificial video cameras used to manage grout fill in selected locations that are difficult to view.
- The use of 3 D physical model at the P and R reactors for sequencing grout placement. The models were also used to familiarize workers with the areas to be grouted. See Figure 6.



Figure 6 – R-Reactor 3-D Model Credit: Savannah River National Laboratories

GROUTING CHALLENGES

Grout Logistics

One of the fundamental observations of ISD projects is the fact that the project is not just a matter of filling a structure with concrete. The experiences at the three sites clearly indicate the enormity of the challenge with regard to logistics and the coordination of many activities, but in particular for procurement, delivery, and placement of grout. Lessons related to the logistics of grout management include the following:

- All the ISD projects benefited from use of on-site batch plants. See Figure 7. Experience at SRS suggests that batch plants be set up on site (even if temporary) should consist of new components to ensure compliance with the latest building codes. Procurement specifications need to delineate all applicable codes that the plant must satisfy.
- When utilizing off-site grout providers, consider a second source of grout (separate company/plant) to ensure or increase productivity.
- At the CPP-601/640 project batch plant capacity was not the limiting factor for grout supply to the project; the pump truck rate capacity was typically the critical element.
- The ISD projects required a significant number of trucks to transport the grout from the batch plant to the job site (i.e., 20 to 22 trucks per shift for the grouting of R Reactor at SRS). The project discovered that the watery consistency of the grout necessitated that the trucks not be filled to capacity so as to prevent spillage during transport. It was also discovered that traffic controls and dedicated haul routes were essential for safety and ability to meet schedule. The increased truck traffic also increased the wear and tear on the roadways and the maintenance of these roads needed to be included in the ISD project baseline.
- Flyash is an essential ingredient for grout that will readily flow through narrow openings and inside of pipes and ductwork ("flowable grout"). At Idaho and Hanford, the delivery of flyash was often on the work schedule critical path. The limited use of coal plants for electricity because of the plentiful availability of hydro power during the time when these projects were conducted meant that concentrated effort was needed to ensure sufficient flyash was delivered when needed.



Figure 7 – Placement of the U Canyon Grout Plant

Grout Placement

The grout formulations used for the INL, Hanford, and SRS ISD projects were designed to fulfill three basic needs: 1) grout for bulk filling of spaces, voids, and tanks; 2) a flowable grout for filling pipes, and 3) a more rigid concrete mix (i.e., with coarse aggregate) for plugs, barriers, replacing walls removed for convenience, and structural reinforcement. Because of the flowable nature of grout, it can be introduced

with relative ease into the "nooks and crannies" of most structures. Engineered placement, (i.e., controlled fill in pre-designed lifts) ensured adequate filling of void spaces. Figures 8 and 9 show grout placement examples.

Placement of grout requires systematic attention to details. A few of the lessons within this report that stood out in particular are as follows:

- At INL grouting of piping was accomplished either by directly filling specified pipe runs or by opening the pipe at specified locations to allow grout to enter during filling of the general area. When piping was filled directly, the amount of grout needed to fill a particular pipe run was precalculated, and if the operation exceeded this amount by 10 percent, filling was stopped to find out why. The longest pipe run grouted in a single operation was about 100 ft (30 m) based on the configuration and impeding components, such as valves, within the system.
- A lesson learned at U Canyon during grouting of the Hot Pipe Trench, where grout did flow through the inverted P Traps escaping into the ventilation tunnel, was to ensure all possible grout flow paths were identified and appropriate barriers are installed prior to grout addition. And if at all possible, the effectiveness of the barrier with "test pours" should be verified before completely filling the area.
- Core drilling was necessary to provide access ports for the introduction of grout into various areas at SRS and Hanford. The U Canyon Project Team suggested that the use of remote technology should be considered for core drilling to reduce personnel exposure and to free up labor resources for other tasks.
- The ISD projects at SRS discovered that concrete mixes with Integral Crystalline Waterproofing additive tend to be difficult to work with because: 1) of the narrow ambient temperature range required for placement, 2) they are prone to setting at an accelerated rate, and 3) the post placement curing requirements are onerous. Specifying the use of ICW should be minimized.
- The heat generated from the hydration of cement in the grout can potentially raise the temperature of a large grouted mass over 100 degrees if not controlled. High temperature during grout curing can thermally stress the grout mass and the reinforced-concrete canyon structure. Temperature induced expansion of the grout can cause cracking of the concrete structure surrounding the grouted voids. At U Canyon, temperature was controlled by limiting the lift volumes, and sequencing the filling of process cells to prevent damage to the curing grout and canyon structure. It is necessary to ensure that concrete curing is performed in accordance with applicable codes and takes into account prevailing weather conditions.
- Grouting of U Canyon process cells was completed in lifts. Concerns over the amount of heat generated during grout curing drove the Project to specify 48-hour interval between lifts; however, temperature monitoring of early pours showed that 24 hours was sufficient for the heat to dissipate to acceptable levels.



Figure 8 – Before and After Grouting of the P & R Reactor Disassembly Basins



Figure 9 – Reactor Vessel Grouting

VARIATION FROM INITIAL PLANS

A key lesson for all decommissioning projects is the need to be prepared for changes as implementation proceeds. The three major ISD projects reported here have required adjustments and changes because of factors such as:

- Details of execution that were not anticipated by those planning the project, in many cases because of information that can only be known as progress is made.
- Physical conditions discovered as the project proceeds that caused difficulties with regard to conduct of work, industrial safety, and /or radiological exposure.
- Inability to meet some individual commitments in environmental and regulatory compliance documents.

Tables 1, 2, and 3 present some of these changes at Hanford, Savannah River Site, and Idaho National Laboratory, respectively. They are described at greater length within the experience report.

The Need for the Change	Change Description/Resolution/Lesson
Demolition Scope	The Change
The original planned final configuration of the U Canyon was that the upper part of the canyon building would be demolished to approximately the level of the canyon deck, and the remnants of the facility would be covered with an engineered cap. The driver for the change	The record of decision was written with flexibility so as to not define how much of the canyon wall would be demolished.
	It was decided for future completion of the project to remove more of the upper structure and collapse the roof to the canyon deck. This will significantly reduce the height and footprint of the final engineered cap.
was a concern that there would not be sufficient cover material on site.	The lesson learned is the wisdom in creating a ROD with such flexibility.
Structural Grout Specification	The Change
The project team's interpretation of a qualitative requirement from the U Plant ROD, specifically the ambiguous phrase "flowable, structural grout with good compressive strength," resulted in the somewhat arbitrary specification of grout with a compressive strength of 1,500 psi (10 MPa) at 28 days.	Field demonstration tests found that grout with a lower strength (in the 500 to 800 psi [3 to 6 MPa] range) would be adequate for the intended purpose of void space fill; structural stability was not a requirement. Subsequent negotiations with regulators, backed by independent quality testing to confirm whether grout supplied in the field met the specifications, resulted in relief from this inferred design requirement. The change contributed to the ability to meet the project schedule.
This significantly impacted the project schedule with regard to meeting quality control requirements that depended on the length of time for samples to develop the required strength.	In this case, those setting the original specification for grout did not consider the effect on project execution. The lessons is that those translating approval documents into project requirements should understand the true need as well as the potential impact on the project.
Tank with Transuranic Isotopes	The Change
Tank D-10 contains liquid and sludge contaminated with transuranic isotopes (TRU). The original plan per the record of decision was to remove any material greater than 100 nCi/g. The need for change was a result of being able to obtain better characterization of the tank contents once entry to the canyon was achieved. It was found that compared with the original characterization the tank contents were greater in volume, sludge fraction, and TRU amount. Removing the contents would have been a technically challenging, expensive, and time consuming project.	The revised approach included complete removal of the tank with contents in place and with absorbent added to stabilize the free liquid in the tank. A custom shielded container was designed and fabricated to facilitate removal and transport to the Central Waste Complex where it was placed in interim storage pending eventual treatment and packaging for shipment to WIPP.
	characterization results that are difficult to obtain prior to the start of work need to be verified as soon as possible.
	See Figure 10.

Table 1 - Project Change Examples at U Canyon



Figure 10 - Removal of Tank D-10 from U Canyon

The Need for the Change	Change Description/Resolution/Lesson
Use of Foam Grout	The Change
Filling the void beneath the floor of the transfer canal that runs between the reactor building and the disassembly basin became a problem caused by contamination and exposure from irradiated scrap on the canal floor. This prevented human access to conduct the core drilling in the canal floor for grout fill.	The original plan was to fill the void with grout to prevent collapse of the canal floor after grouting. To prevent canal floor collapse, part of the fill used in the transfer canal was revised from the flowable structural fills to a lightweight (foam) grout. The grout was specified to ensure the canal floor loading would be the same or less than when the canal was water filled. The lesson here is a standard one for decommissioning projects; that is, unexpected conditions will be encountered for which alternate methods will be needed.
Disassembly Basin Robustness	The Change
The demolition proved to be a major challenge because of the robustness of the structure and the presence of significant amounts of reinforcing steel. Even with the larger equipment than planned, demolition took almost twice as long to complete than estimated.	The Project Team recommended that for the remaining three reactors at SRS, the above-grade structure of the Disassembly Basin not be demolished. Rather, all external openings on the above-grade structure would be closed to allow filling the entire above-grade void with non-structural grout resulting in a monolith atop the grout-filled basin. The savings in avoided demolition labor greatly offsets the cost of the non-structural grout required to fill the above-grade void space.
	Other non-ISD projects have encountered similar demolition issues when there was insufficient knowledge and/or characterization of the strength of a facility's concrete material and rebar. The lesson is that for demolition of robust facilities, advance planning should ensure sufficient information has been gathered to well understand what will be required. If there is insufficient information from drawings and specifications (or doubts as to its validity), the concrete properties (e.g., with a core bored sample) and the rebar configuration and size should be determined.

Table 3 - Project Change Examples at INL Buildings 601/640

The Need for the Change	Change Description/Resolution/Lesson
Process Cell Sample Blisters	The Change
Original planning was to remove all steel- encased lead "blisters" used for removal of sample containers. The blisters were attached to the outer walls of process cells in Building 601. Because of the lead, the intent was to remove the lead to satisfy RCRA requirements. However, removal of many blisters would have been extremely difficult because of tight access and radiation exposure to workers.	Blisters on grade level were removed by demolishing an exterior wall and using an excavator to rip out and handle the sample blisters. The exterior wall was re-formed and rebuilt with structural concrete. A waiver was obtained to leave the lead in place associated with the blisters in difficult to access locations. Worker safety and potential personnel exposure outweighed the benefit of removal. Again, the lesson here is a standard one for decommissioning projects; that is, unexpected conditions will be encountered for which alternate methods will be needed.

The Need for the Change	Change Description/Resolution/Lesson
Above Grade Process Cell Protrusion	The Change
The tops of three process cells that protruded above grade within Building 601 were planned to be demolished. However there were significant safety risks related to cutting equipment in cramped quarters and the associated personnel radiation exposure.	The Citizen's Advisory Board recommended that these cells be left intact to be grouted and integrated into the area cover system. The lesson here is that involved stakeholders with an interest in finding practical solutions can greatly benefit a project. Figure 2 shows the cover system.

CONCLUSIONS

Like many industrial projects, ISD projects are complex and massive, involving activities that include contracting, engineering, mobilization, preparing the facilities for extended grouting campaigns, and conducting the grouting along with many parallel tasks; all of which follow prerequisite and ongoing characterization activities to define the physical condition of the facility and its materials. Each project presented a huge logistical challenge due to the amount of materials, construction equipment, protective safety equipment, and other requirements, all with varied sources of supply and demanding critical timing to ensure availability when needed. As a result, many of the lessons learned are similar to management and execution of industrial projects.

The mix of construction type activities combined with these conditions provides the primary lesson of this paper. The project staff that will manage, plan, and implement an ISD project must be prepared to conduct many tasks akin to construction projects in addition to the challenges of and activities for decommissioning a contaminated facility.

The experience report will greatly benefit Federal Project Directors, project managers, engineers, and planners that will plan future permanent entombment of contaminated facilities. It provides a means for gaining understanding of ISD projects by regulators and other stakeholders involved with decommissioning of DOE facilities.

REFERENCES

1. DOE EM Strategy and Experience for In Situ Decommissioning, Prepared By U.S. Department of Energy, Office of Environmental Management, Office of Engineering and Technology, EM-20, September 2009. This report can be downloaded from http://energy.gov/em/downloads/doe-environmental-management-strategy-and-experience-situ

2. DOE EM Project Experience & Lessons Learned for In Situ Decommissioning, U.S. Department of Energy, February 2012. This report can be downloaded from <u>http://energy.gov/em/downloads/doe-em-project-experience-lessons-learned-situ-decommissioning-feb-2013</u>

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