**Project Name:** RL-B309-Pu Recycle Test Reactor-D&D

**Project Name (Expanded):** Richland Operations B309-Pu Recycle Test Reactor-D&D [Deactivation, dismantlement, and demolition of a medium-sized reactor, with a smaller reactor and hot cell adjuncts]

**Project Type:** Building / Facility D&D Project Type

**FIMS Hazardous Category:** 04 Radiological Facility (previous Building Type 2)

**Project Type Detail:** Reactor - Test/Small Experimental

**Supplementary Reference Documents** Facilities Status Change Form, dated 3/18/15

**Site Context:**
The historical Hanford Site mission was to reprocess reactor core material to produce plutonium for nuclear weapons and fabricate nuclear weapons components. It originally covered 670 square miles, and it has no future major non-environmental mission (there will be minor laboratory operations, management of waste disposal facilities and legacy controlled areas, and a gravity-wave observatory.

The two major activities associated with the DOE-EM mission are the facility decommissioning, environmental cleanup, and transuranic and solid waste management performed by PRC and WCH, and the vitrification/stabilization of high-level waste held in large below-ground tanks by WRPS. Previously, ECAS projects had collected costs and parameters from ARRA work performed between 2009 and 2013. This iteration of ECAS cost and parameter collection evaluated all potential projects conducted under the PRC and WCH contracts and selected specific projects for inclusion in the ECAS database based on the needs for specific historical data. Since the number of ECAS projects is relatively limited, the Hanford EM scope has been divided into two ECAS Level 4 Parent Projects based on the Hanford organizational and PBS groupings.

**ECAS Level 4/Parent Project Context:**
The Parent Project grouping includes the ECAS Projects executed under the Washington Closure-Hanford (WCH) “River Corridor” contract; they comprise a small fraction of the total contract. These projects were in areas located relatively close to the Columbia River, and included plutonium production reactors (the “100 Areas”) and the generally research and special projects facilities (the “300 Area”), as well as the general waste management area. The selected ECAS Projects are as given below:

- RL-B329- Chemical Sciences Laboratory
- RL-B340- Waste Neutralization Building
- RL-B309- Pu Recycle Test Reactor - Offices - Shop/Sp-100 Gas Test Facility
- RL-B326- Material Science Laboratory
- RL-B327- Post Irradiation Test Lab
- RL-B3730- Gamma Irradiation Facility
- RL-B308- Fuels Development Laboratory
- RL-Waste Ops-ARRA ERDF Construction Super Cell 9
- RL-Waste Ops-ARRA ERDF Construction Super Cell 10
- RL-B337- Tech Management Center
- RL-Waste Ops-ARRA Disposal, Treatment, and Transportation
D&D Facility Data:
Facilities (FIMS data where possible):

<table>
<thead>
<tr>
<th>Building (Property ID)</th>
<th>Title (Property Name)</th>
<th>Area (SF)</th>
<th>Year Built</th>
<th>Contamination Category</th>
<th>Hazard Category 1</th>
<th># of Floors</th>
</tr>
</thead>
<tbody>
<tr>
<td>309</td>
<td>Pu Recycle Test Reactor</td>
<td>46,708</td>
<td>1960</td>
<td>Not Given</td>
<td>10 BSL-3 Facility</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: Despite the Hazard Category given in FIMS, this was not a BSL-3 Facility; it should have been classified as a Radiological Facility or Nuclear Facility Category 3, depending on its MAR.

Construction Details:
Building 309 was composed of two major parts; a cast concrete “dome” containing the PRTR reactor, and an attached support and associated laboratory structure (containing a small second reactor among other equipment). The support structure appears from pictures to be mostly one story with smaller second story areas, and generally masonry although there is likely some support steel, and some basement areas. The reactor dome portion was generally open space from grade level up, and contained a pressure vessel and various equipment and structure below grade to a considerable depth. Several photographs are provided below:

Photograph 1. Aerial photograph showing the 309 Reactor, view facing west (circa 1980s).

Photograph 2. Aerial photograph showing the primary containment dome removed, view facing west (1/19/11).
Photograph 3. Aerial photograph showing above-grade demolition progress, view facing south (10/20/11).

Photograph 4: Aerial photograph showing completion of above-grade demolition and preparations for reactor core removal, view facing west (9/10/13).
Photograph 5: Aerial photograph showing the heavy lift assembly in preparation for reactor core removal, view facing east (1/15/14).

Photograph 6: Reactor core lift, view facing west (1/21/14).
Photograph 7: 309 primary containment following explosive fracturing, view facing northeast (9/29/14).

Photograph 7: -32 foot primary containment monolith, view facing south (2/24/15).
Facility Use:
309 Plutonium Recycle Test Reactor
The PRTR was an 85 vertical tube, heavy water moderated, light water cooled, 70 MW nuclear reactor that operated from 1960 to 1968. The PRTR first went critical on November 21, 1960 and its last full power operating day was July 13, 1968. A secondary test reactor, the Critical Test Facility (CTF) was added to the east wing of the 309 Building in 1962 to support the PRTR operations and later to support commercial nuclear reactor fuel management data needs. The CTF was operated until 1976 when fuel management computer models replaced the need for the fuel performance measurements.

The PRTR was operated in support of the Plutonium Utilization Program to develop an optimum reactor fuel design for recycling plutonium to stretch the uranium fuel supply for commercial nuclear reactors. In 1963, operation of the Fuel Element Rupture Test Facility (FERTF) was started using one of the standard 10 cm (4 in) diameter PRTR process tubes with up to 2 wt. % plutonium oxide. Fuel and fuel cladding tests were done at elevated operating temperatures and with pre-defected fuel to evaluate fuel design limits. In April 1965, the FERTF test loop was connected to the largest, central PRTR tube No.1550 that was about 18 cm (7 inch) diameter. Fuel performance testing continued at increasingly higher enrichments and higher fuel temperatures including partially molten conditions beginning in May 1965.

On September 29, 1965, while operating a pre-defected U0 2-4 wt. % PuO2 fuel rod at 1,790 KW power level, a serious fuel failure accident occurred. About 75% of the fuel rod radius was molten when the pin hole enlarged to 5/8-inch, the fuel rod ruptured, and the surrounding FERTF/PRTR process tube was breached. The breaching of the process tube contaminated the helium gas in the space between the process tube and the aluminum shroud tube. Fission gases released during the rupture traveled through the helium system and into the HEPA filtration system for the process off-gases. Airborne contamination reached 20 R/hr within the reactor main hall (i.e., contained by the dome). But the most serious contamination was within the primary and secondary coolant systems due to the fuel material released. Calculations determined that 705 grams of fuel (about half of the rod's contents) was released, grossly contaminating the PRTR's heavy water coolant and moderator with fission products, mixed oxide fuel, and light water (i.e., FERTF coolant).

Following the fuel failure, reactor recovery involved gross decontamination of the operating area, removal of the fuel element and process tube, and finally a detailed decontamination of the operating area that required a total of six (6) months. The PRTR was restarted in July 1966 and operated until mid-1968 when it was shut down for a valve replacement. However, before the repairs were completed, the Atomic Energy Commission (AEC) decided to shut down the PRTR program to pursue an alternate breeder reactor technology. The PRTR layaway and decommissioning began in 1969 and was completed in November 1969. The fuel was removed and reprocessed on site, the heavy water was shipped to the Savannah River Plant, and the removal of major equipment for reallocation or burial was begun. From 1970 to 1975, the PRTR deactivation continued with the deactivation of the major associated facilities and the associated concrete structures in 1975.

In 1975, the Interim Examination and Maintenance (IEM) cell was built within the old maintenance and mockup cell area in the west wing. The IEM included a tower at the east end of
the west wing. The IEM was an exact "cold" replica of the operating cell in the FFTF reactor and was used to train and requalify operators and to check operating procedures.

During the PRTR deactivation, the CTF operation was continued until 1976 for the AEC and the Nuclear Regulatory Commission's support of the commercial nuclear energy programs. The CTF's closure came when computational tools for nuclear reactor fuel management became advanced enough to replace the need for the PRCF's testing capabilities. In 1988 to 1989, the CTF hardware and equipment were removed and disposed of in the 200 Area burial grounds.

In 1986-87, a new space technology development program known as SP-l00 was assigned to the 309 Building. The implementation of the SP-100 Ground Engineering System Test Facility involved an extensive cleanout of old PRTR facilities, the installation of the 3701U Guard Station in the northwest corner of the 309 Area and enclosure of the 309 facilities within a fenced security area. In 1991, the SP-100 program was placed on a 5-year "hold" and subsequently terminated by the DOE in November 1993 which brought about the transition of the facility for deactivation.

The 309 facilities were located in the south central 300 Area between Arizona Street on the west, New Mexico Street on the east, Locust street on the north, and Cypress street on the south below 309 Area parking lot. The distinctive round PRTR dome was a 300 Area landmark.

Processes causing contamination: See above

<table>
<thead>
<tr>
<th>Building</th>
<th>Chemical Hazard</th>
<th>Location/Extent</th>
<th>Radiological Hazard</th>
<th>Location/Extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>General buildings</td>
<td>Asbestos, Beryllium, and</td>
<td>ACM was present in almost every conceivable form and function. ACM included, but was not limited to friable</td>
<td>Radiological Survey Results ranged across the spectrum of radiological conditions; Radiological Buffer Area, Contamination Area, High Contamination Area, Radiation Area, Radiological Material Area, High Radiation Area, and Airborne Radiation Area.</td>
<td>Process and mechanical areas; Reactor Containment area</td>
</tr>
<tr>
<td></td>
<td>incidental heavy metals</td>
<td>Thermal Systems Insulation, non-friable Category I materials (roofing, gaskets, and resilient flooring) and category II nonfriable materials (transite, mastics, putty, floor tiles, ceiling panels, etc.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D&D Project Execution

Site WBS Organization within the ECAS Project Scope:

Deactivation: Utility isolations were performed on the facility prior to beginning facility decontamination. The following hazardous materials were removed prior to facility demolition: oils, batteries, Freon, lights, light ballasts, asbestos containing materials, mercury switches, glycols, tritium exit signs, lead, and radioactive materials. Hazardous material removal and waste disposition was performed in accordance with Removal Action Work for 300 Area Facilities, DOE/RL-2004-77, Revision 2 (RAWP). Asbestos removal was conducted by certified asbestos workers.

Demolition: Above-grade demolition of the 309 Plutonium Recycle Test Reactor was completed in 2014. Below-grade and removal of structures that included the reactor core, tanks, piping, ion exchange vaults, rupture loop annex, IEM cell, south annex and the fuel storage basin were completed January 2015. The 309 primary containment vessel was removed to -32 feet below-grade, with the rest of the structure remaining in place. All demolition debris and facility components (e.g., reactor core) were removed and disposed of at ERDF. The demolition was
performed under radiological and Industrial Hygiene controls. GPERS surveys and backfill of the 309 excavation are deferred to completion of remedial actions associated with waste sites 300-22, UPR-300-5, and 300-255.

Description of Current/As-Left Conditions:
The lower 309 primary containment vessel remains in place at -32 feet at the bottom of the excavation. The excavation remains open with access restricted through radiological and industrial hygiene postings.

Documented Waste Sites: 300-22 (309 Building B-Cell Clean-out Leak); UPR-300-5 (309 Fuel Storage Basin Overflow); 300-255 (309 Tank Farm Contaminated Soil)

The PRTR layaway and decommissioning began in 1969 and was completed in November 1969 as discussed above. From 1970 to 1975, the PRTR deactivation continued with the deactivation of the major associated facilities and the associated concrete structures in 1975. It is unclear what was removed during this period; this work is not included in the ECAS project. On-going radiological operations continued, and additional radiological equipment was installed.

After completion of hazardous material removal and component stabilization, demolition began in 2011 with removal of the containment dome and demolition of the south and east annexes. Following this first phase of demolition, the next two years were devoted primarily to removal of the 309 reactor core. This was accomplished by wire sawing the concrete around the outside of the biological shield and then lifting the reactor from below-grade with a heavy lift assembly. After the reactor was removed, the final phase of demolition was initiated and included explosive fracturing of the substantial below-grade concrete structures located inside the primary containment vessel and standard demolition of associated and adjacent structures. This final phase of demolition was completed in January of 2015. The only remaining 309 structure consists of the lower containment vessel concrete monolith at the -32 foot level. The lower containment structure and adjacent soils underwent closure characterization sampling through January of 2015 (reference Attachment 5). A subsequent evaluation of the data established that protectiveness of groundwater and the river were achieved (reference Attachment 6). Beta and Gamma Global Positioning Environmental Radiological Surveys (GPERS) were conducted on the -32ft monolith surface (Attachment 3). Radiological contamination was identified; however, core sampling demonstrates residual contamination achieves 300-FF-2 Cleanup Levels. GPERS surveys of adjacent soils will be conducted as part of remedial actions associated with adjacent waste sites.

Anomalies Discovered During Demolition:
No true anomalies were discovered during demolition and remediation. A casing from long-decommissioned ground water monitoring well 399-4-5 was encountered beneath the south annex basement floor and was removed to the extent of the overall excavation. No other unusual items or soil conditions were observed during demolition and remediation.

Methods of execution:
Management: The scope was planned, managed, and executed as a single element. Management included technical and project oversight, planning, project controls, and quality assurance.
Regulatory: An EECA was prepared to determine the appropriate disposition alternatives. Hazardous material removal and waste disposition was performed in accordance with Removal Action Work for 300 Area Facilities, DOE/RL-2004-77, Revision 2 (RAWP).

Physical Approach:
- Initial characterization, and planning using detailed work packages
- Removal of process equipment - manually removed process equipment using various contamination containment approaches and using hand-held power-tools.
- Abatement of asbestos from all friable sources (principally insulation and interior transite)
- Conventional demolition and loadout of remaining structure for those areas outside of the reactor dome; less-contaminated equipment was size reduced as part of the building
- Removal of the upper dome by crane; explosive fracture of massive concrete structural components.
- Removal of sub-grade large components, packaging, and disposal at ERDF
- Removal of the pressure vessile and remaining internal components as one piece and disposal at ERDF
- Removal of remaining sub-grade concrete structure with exception of “base plate: foundation.
- Characterization and backfill

Technologies: Normal D&D activities for non-reactor areas. Use of large crane to remove upper reactor dome for access and to remove large components. Packaging of highly radioactive components for single disposal instead of dismantlement.

Activities self-performed:
- All management and key technical positions along with a portion of the technical staff
- All of the Site hourly labor doing the physical removal of process equipment
- Decontamination of structural surfaces
- Waste management and disposal
- Used significant professional services contracted (i.e., seconded) labor inter-mixed with prime contractor staff

Activities subcontracted:
- Removal of non-process equipment
- Characterization of surfaces prior to demolition, and sample analysis
- Waste treatment of mixed wastes (on-site and off-site)
- Demolition of structures

Issues that impacted the project:
- None; no “anomalies” were identified.

Scope Growth:
None identified.
Notes Regarding Use of Data

- Significant questions about how much reactor equipment was removed in the 1970-2010 period; should be considered only partial reactor dismantlement, although some new radioactive materials/equipment were introduced as part of revising the building’s mission.
- A small portion of the below-grade structure was left, and backfill was deferred.
- Waste values were provided only for the volumes of waste sent to ERDF; no values were given for anything other than LLW (presumably bulk) and any MLLW that would meet the ERDF WAC. TRU, high-level, hazardous, or MLLW that required treatment or did not meet the WAC are not accounted for. It is likely that little sanitary waste was generated. The waste values include both waste from the D&D and from the associated remediation as shown below (in units of Cubic Feet):

<table>
<thead>
<tr>
<th>Site</th>
<th>Volume (Cubic Feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>309 - Remediation</td>
<td>1,323,180</td>
</tr>
<tr>
<td>309 - D4</td>
<td>558,222</td>
</tr>
<tr>
<td>309-TW-1 - Remediation</td>
<td>44,276</td>
</tr>
<tr>
<td>309-TW-2 - Remediation</td>
<td>45,999</td>
</tr>
<tr>
<td>309-TW-3 - Remediation</td>
<td>43,849</td>
</tr>
<tr>
<td>309-TW-3 - D4</td>
<td>618</td>
</tr>
<tr>
<td>309-WS-1 - Remediation</td>
<td>398,785</td>
</tr>
<tr>
<td>309-WS-2 - Remediation</td>
<td>38,689</td>
</tr>
<tr>
<td>309-WS-3 - Remediation</td>
<td>18,056</td>
</tr>
</tbody>
</table>

The excavation and waste management costs for the 309-TW and 309-WS waste sites appear to be addressed in separate remediation WBS elements, so the only waste volumes included in the database are for the 309 building and associated adjacent soil.