Savannah River Site Operating Experience with Transuranic (TRU) Waste Retrieval

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ABSTRACT

Drums of TRU Waste have been stored at the Savannah River Site (SRS) on concrete pads from the 1970s through the 1980s. These drums were subsequently covered with tarpaulins and then mounded over with dirt. Between 1996 and 2000 SRS ran a successful retrieval campaign and removed some 8,800 drums, which were then available for venting and characterization for WIPP disposal.

Additionally, a number of TRU Waste drums, which were higher in activity, were stored in concrete culverts, as required by the Safety Analysis for the Facility. Retrieval of drums from these culverts has been ongoing since 2002.

This paper will describe the operating experience and lessons learned from the SRS retrieval activities.

INTRODUCTION

Operations at the SRS routinely generate radioactive waste, including solid and liquid wastes. This paper addresses solid waste and specifically TRU waste that has been generated by the process facilities on site. The term "TRU waste" was originated in 1970 following a directive from the Atomic Energy Commission (AEC) to segregate and retrievably store waste having transuranic isotopes with atomic numbers greater than 92 and half lives greater than 20 years. This waste was termed TRU waste and was required to be retrievably stored in contamination free packages designed to last greater than 20 years.

Prior to 1970 no such segregation of TRU waste was performed. This pre-1970 waste is contained in Old Radioactive Waste Burial Grounds (ORWBG) at a number of DOE sites and is the subject of national policy that is seeking a path to rationalize its treatment / storage, complex wide. Consequently, this paper does not address the pre-1970 waste and is therefore focused on the retrieval and disposition of TRU waste only. It should be noted that, unlike the TRU waste, this waste is not segregated for transuranic isotopes or retrievably stored and, therefore, represents a very different retrieval scenario.

Since the 1970s, TRU waste has been generated through execution of national defense programs and retrievably stored at the Savannah River Site for eventual disposal at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. The waste is contained in steel boxes, 55-gallon drums (i.e., $.2082m^3 = .21m^3$), 85-gallon drum (i.e., $.3212m^3 = .32m^3$) overpacks and drums within concrete culverts, which were placed on concrete slabs called TRU pads. Within the Solid Waste Disposal Facility (SWDF) at SRS, there are 25 TRU pads. Pads 1-6 were the earliest constructed and started to receive waste during the early 1970s. As the pads were filled, they were covered with a light sandy soil; a weatherproof tarp was added; and, finally, they were mounded with a heavier loamy soil. The weatherproof tarp and the loamy soil were intended to provide protection from water ingress and the light sandy soil was placed to facilitate ease of retrieval and entrain any contamination that may have egressed from the drums. This practice of mounding the pads ceased in 1985 prior to completing Pad 6. Subsequent pads were not placed under earthen mounds and the 55-gallon TRU drums were fitted with WIPP Nucfil^R filter vents. Pads 7 - 13 were open and Pads 14 -19 were covered by weatherproof enclosure buildings. The uncovered drums on

Pads 7 through 13 accumulated water from rainfall, which penetrated the filter and accumulated in the drums. These drums were radiographed, dewatered and moved to covered storage in the early 1990s.

Operating procedures required all of the drums in temporary storage on the pads to contain less than 0.5 PEC (Plutonium Equivalent Curies). This is of the order of 8 grams of fissile material per drum. This factor influenced the development of the retrieval methodology because the source term was considerably less than that of similar TRU storage sites in other areas of the DOE complex.

The SRS TRU waste, which is referred to as legacy waste, had grown to over 11,000m3. Although project development work had been ongoing since the early 1980s to develop TRU facilities for processing, little or no actual progress had been made. In 1997, however, the TRU program switched gears from just continued storage to a multifaceted program designed to begin retrieval and preparation of containers for shipment to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM. The following activities reflect this progress in the TRU program.

TRU WASTE RETRIEVAL AND DISPOSAL AT SRS

BNG America, Savannah River Corporation, the operating contractor for the Waste Management Area Project at SRS, is responsible for the retrieval and disposal of TRU waste from the pads at SRS. The inventory of TRU waste that this project represents can be summarized as 11,650 cubic meters of legacy inventory, containerized in the following:

- 30,000 55-gallon galvanized carbon steel drums
- 2000 large boxes and non-drummed TRU waste containers
- Containers range in fissile inventory from 0.5 curies to 1,500 curies of weapons grade and heat source plutonium.
- Container storage areas included earthen covered concrete pads containing drums, drums in culverts (higher activity) and large boxes, RCRA regulated fabric covered buildings for drums and open storage for culverts and large boxes.

Drum Retrieval/Vent and Purge

Starting in January 1997 through August of 1999, over 8,800 drums of TRU waste were retrieved from earthen covered mounds; inspected, vented, and purged of radiolytic gases; and re-stored in aisle-spaced fabric-covered buildings. This was a major project activity, completed two years ahead of schedule, eliminating concerns about the condition of these containers, which had been under earthen cover for over 20 years. Also these containers, all of which were produced prior to 1986, did not have filter vents installed in the drum lids.

TRU Waste Drums Before Retrieval

TRU Waste Drums After Retrieval

Fig. 1. TRU waste before and after retrieval.

As part of the retrieval program, all these containers were processed through the Drum Vent and Purge system, where radiolytic gas (primarily hydrogen) and other gasses such as methane and volatile organic compounds (VOCs) were vented and a carbon filter inserted to prevent the recurrence of gas accumulation. To date some 25,000 drums have been processed through this system (including non-retrieved drums).

Ship to WIPP program

In 1998, a Ship to WIPP effort was initiated with emphasis on developing the process, procedures and facilities to meet the requirements of the WIPP Acceptance Criteria and the New Mexico Resource Conservation and Recovery Act (RCRA) permit. This included the installation of characterization facilities including headspace gas sampling and analysis and non-destructive assay and radiographic equipment. Existing facilities were modified to accept the TRUPACT-II loading platform. A new facility was constructed, the Visual Examination Facility, which provided verification of drum contents identified through radiographic analysis.

This facility is another example of "fit-for-purpose" capability provided at relatively minor cost by using existing infrastructure and equipment. The site was successful in passing a certification audit in November of 2000. The first shipment of 42 drums was made on May 8, 2001. Since then, an additional 16,000 drums (over 500 shipments) have been sent to WIPP. The site anticipates that the shipment numbers will continue to increase with disposition of all of the legacy TRU waste by 2014.

Early completion of the legacy TRU waste retrieval and shipping mission at SRS by moving this waste into safe permanent disposal at WIPP by 2014, twenty years ahead of schedule, represents a saving to the taxpayer of approximately $700 million. Subsequently, this brings the scheduled completion date forward by 20 years from the original baseline of 2034 to 2014. This has been achieved through adoption of risk informed decision making to accelerate the safe and cost efficient clean up activity. All of this has been achieved without a single reportable safety event.

RETRIEVAL ACTIVITIES AT SRS

Planning efforts to retrieve the TRU waste from the earthen mounded Pads 2 through 6 began in the early 1990s. Pad 1 was not included as it contained heat source waste that was being considered for recycle. Planning activities included technology development, hazard analysis and development of regulatory instruments and working procedures.

Initial hazard analysis performed during 1994 established process controls and safety significant process steps and equipment; predominant hazards were radionuclide contamination egress from the stored drums and the potential for buildup of radiolytic gasses in unvented drums. Risk mitigation was focused upon remote operations to protect workers from handling drums containing potentially flammable gasses, the use of enclosures and ventilation systems to control contamination. However, as initial investigation work progressed on the pads, the ability to apply a more risk informed approach evolved. Soil sampling indicated very little contamination egress from the drums and drum head space gas sampling indicated a lower probability of encountering potentially flammable drums.

The inclusion of field data about the condition of the drums and pads allowed for the removal of conservatism in the hazard analysis and definition of a more accurate model for calculating the risk to the co-located worker. Consequently, taking a risk informed approach to the development of the hazard analysis and flowing it down to implementation of a remediation strategy for the TRU pads allowed a refinement of remediation operations to be performed. This removed a number of unnecessary controls. Fig. 2 shows the initial process steps that were envisaged for remediation of the TRU pads. The final strategy employed at SRS, which was based upon the revised hazard analysis, resulted in open air excavation and handling of multiple drums during an excavation cycle.

The retrieval methodology for the mounded TRU pads was accepted in 1995 and in essence had become an extension of routine operations within the solid waste handling area. This was achieved through careful analysis of the added risk of the excavation operations and by demonstrating that it was simply an extension of current burial ground operations and required only minor modification of burial ground operating procedures. TRU waste retrieval operations from the pads were incorporated into the SWDF Basis for Interim Operations. A developmental approach was taken to initiation of operations, particularly the vent purge system. The vent and purge system supplied and operated by Nuclear Filter Technology Inc. was based upon a LANL system and evaluated as a Hazard Category 3 nuclear facility. As such it could be demonstrated that neither Readiness Assessment nor an Operational Readiness Review was required.

Programmatically a number of initiatives were implemented to expose the TRU retrieval project to a rigorous review. These included establishing a dialogue with South Carolina Department of Health and Environmental Control (SCDHEC) to review soil sampling activities for release of the burial grounds; establishing an open door policy to allow regulators and stakeholders access to review the project documentation at any time; and establishment of a national Independent Scientific Peer Review (ISPR) to address any concerns raised by the stakeholders and public. The SRS Citizens Advisory Board was instrumental in requesting the ISPR address their concerns regarding the TRU waste retrieval program at SRS.

In summary, it was concluded that the TRU retrieval project presented no additional risk, outside the acceptable activities at SRS and that the project did in fact address a critical near term safety risk at SRS, which was the retrieval and RCRA compliant storage of potentially corroding, buried TRU waste.

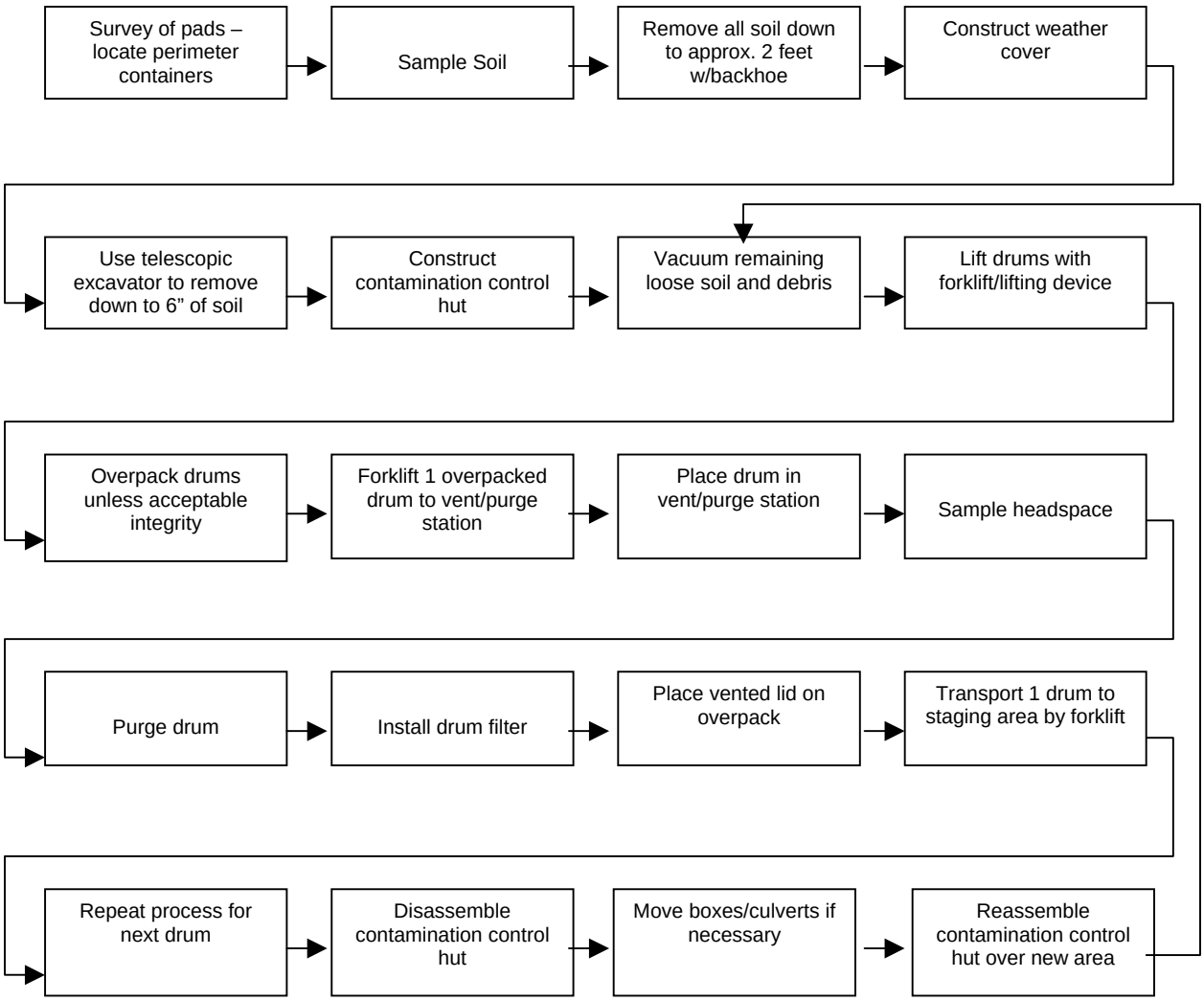

Fig. 2. Retrieval process prior to detailed hazard analysis

Scope of the Retrieval Process

Initially the planned scope was to retrieve 8,800 55-gallon drums from pads 2 – 6. The primary safety concerns were drum integrity failure and the potential for explosive gas mixtures in unvented drums. Stringent controls were planned in order to mitigate the safety concerns, including use of a ventilated enclosure, exposure of only 8 – 16 drums at a time using a remote telescoping arm, and handling only one drum at a time which would be overpacked and vented as it was removed. It was recognized that the controls, if applied, would significantly extend the schedule and cost of the retrieval operations and, therefore, an effort was conducted to improve the definition of the hazard and refine the safety analysis accordingly.

Improved definition of the hazard presented by retrieval operations could only be defined by invasive operations within the pads to determine the condition of the drums. Three techniques were employed: 1) ground penetrating radar was used to identify the location of the drum arrays; 2) soil sampling was employed to determine the extent of any radionuclide contamination that would be indicative of drum integrity failure; and 3) test drums buried in the early 1970s were exhumed and examined.

In addition to the intrusive data gathering effort within the pads, a comprehensive accident analysis was performed using the results of the data gathering effort, including:

- Drum rupture externally induced
- Vehicle collision
- Fire
- Deflagration due to retrieval activities
- Deflagration due to vent and purge activities
- Worst case accident; i.e. tornado / earthquake

This activity coupled with the safety analysis and independent review findings concluded that a number of initially planned project controls and safety related systems were not required and in some cases they actually detracted from safe operations. These included:

- Unnecessary retrieval equipment was deleted and only one piece of equipment would be deployed and that would be a forklift with a drum handling device (grabber)
- Findings of initial hydrogen concentrations in the vent and purge facility demonstrated a much lower frequency of potentially explosive gas mixtures, therefore overpacking all drums was deleted. Additionally this decision was supported by findings that showed drum integrity was far better preserved than anticipated, with a total of only 113 drums requiring overpacking due to compromised integrity.
- Minimal soil contamination and reduced risk of a drum deflagration allowed the deletion of the HEPA filtered containment structure and later the deletion of modular RUBB^{R} building containment. Pads were to be excavated in the open air.

Retrieval Methodology

Information regarding the contents and location of the TRU drums at SRS was contained in the Computerized Burial Records Accounting (COBRA) database. The database contains limited information on the stored containers (isotopic distribution, generator, date shipped, date received, date placed, dose and specific drum number) as well as the location of a drum (given only by grid coordinates of the area). Consequently the exact location of any drum was not precisely known but could be targeted within a grid area within the pads.

COBRA data was routinely applied during retrieval operations particularly in the circumstance of a corroded or otherwise suspect drum being identified. Initial retrieval work was performed using hand tools to remove soil, and a forklift with a drum grabber was used to handle drums. A radiation technician was present during each drum retrieval to perform contamination and dose rate checks as the drum was held by the forklift grabber. Drums were sentenced to interim storage based upon condition and dose rate. No contamination was found. Four operators ran the retrieval operations with responsibility for cleaning and labeling drums, attaching bar codes and performing paperwork.

Following initial characterization of the mound soils, no additional monitoring or pre-sampling was done during excavation of the TRU drums. The initial characterization of soil indicated a very small amount of Tritium. Further samples were taken in the area, with no tritium found. The soil in this area was

packaged in 55-gallon drums for disposal. In total, only 12 drums of contaminated solid were generated; the remaining overburden soil was used as backfill to Low Level Waste (LLW) areas and as needed throughout the SWDF. Soil removal posed no hazard increase to workers during the handling and movement of TRU drums although there was a requirement for coverage by Radiological Control Operations while retrieval operations were in progress. The retrieval area at SRS was roped off as a Radiation Area. The Radiological Work Permit (RWP) specified that the retrieval pad sites were not airborne radioactive areas and they were roped off and marked Radiation Area. Specified PPE was toe protectors, gloves and safety glasses. Operators wore coveralls while conducting retrieval operations. The RWP defined worker responses if a contaminated, damaged or leaking drum was excavated. A hand held volatile organic carbon (VOC) detector was used at the dig face to "sniff" for VOCs, an indication of a loss of drum integrity.

The drum retrieval rate for the 8,800 drums retrieved from the pads 2 -6 was approximately 40 drums per 10-hour day. After the bulk of the earth was removed by heavy equipment, the drums were excavated by an operator using hand tools. The forklift operator then lifted the drum to allow an operator to inspect behind and beneath the drum for signs of corrosion or defects. The drum was then brought to a central work area in front of the pad where the Radiation Technician completed the drum survey. The drum was then examined by an operator in the drum stacking area and appropriate paperwork was generated and bar codes applied to drums.

Any retrieved drums that had a radionuclide content >0.5 Curies (-8.2 grams Pu-239 equivalents) of TRU radionuclides (COBRA indicted less than 40 drums >0.5 Ci), dose rates indicative of weapons grade quantities above criticality limits, dose rate >200 mR contact, surface contamination or evident corrosion problems were individually staged for subsequent evaluation and appropriate disposition. Of the 8,800 drum retrieved from the pads, only 12 had corroded and suffered a pin hole loss of confinement, requiring overpacking. There was no soil contamination found in the vicinity of the compromised drums.

Retrieved drums, boxes, and culverts are maintained in RCRA permitted storage with their original generator assay values, pending submission into the Ship to WIPP campaign.

The SRS TRU drum pad storage was only to contain drums with <0.5 Curies (-8.2 grams Pu-239 equivalents) of TRU radionuclides although some drums were found that contained 20 to 30 grams Plutonium. All drums containing >0.5 Curie TRU radionuclides were placed into concrete culverts. Some of the casks and boxes collocated with the drums in the pads had contact dose readings up to 600 mR. These were then stored in the culverts for ALARA reasons.

LESSONS LEARNED

The TRU waste retrieval project was completed in 2000 with only Pad 1 drums remaining. These drums will be excavated and assessed to determine if they meet WIPP disposal criteria for TRU waste in which case they will be diverted to the RCRA storage pads. The remaining waste containing high levels of heat source plutonium is planned to remain at SRS pending DOE and Regulatory approvals. A number of valuable lessons were learned during the retrieval project and are summarized below:

- Approximately 50 drums (None with containment loss) required overpacking because of drum corrosion, versus the anticipated 50% that were initially thought to be present. It should be noted during future planning efforts for retrieval of buried TRU waste that caution in the absence of actual data regarding buried waste will add to cost and schedule of the retrieval operation. (over 2,000 drum overpacks were purchased and not needed)

- Retrieval operations were successfully completed in the open air environment with only one piece of mechanical equipment, a forklift with a drum "grabber" attachment. There were no instances of loose or airborne contamination and no hazardous or flammable gasses were detected during retrieval operations. This clearly demonstrates that prior project planning that targeted the use of remote systems within fixed containment were unnecessary and would have added unwarranted project cost and schedule.
- Small, highly trained work crews who developed operational expertise as a "learn and repeat" exercise were able to exceed performance goals by 100 percent. This demonstrates the efficiency of deploying skilled workers within clearly defined procedures for the safe and efficient completion of challenging industrial and radiological work scopes.
- Most importantly, the project demonstrated the integrity of the 55-gallon drums as interim storage containers for TRU waste. Having been stored for nearly a quarter of a century in a wet underground environment, 50 of the retrieved drums required overpacking and due to slight corrosion occurring within the bottom 10 centimeters of the drum.
- In a number of instances, the generator values for fissile inventory of the waste drums were found to be grossly underestimated, most notably a drum with 525 g of fissile material that had a zero generator value. This not only presents a nuclear safety hazard to operations but, in addition, presents a challenge to the project Authorization Basis.

CONCLUSION

Rigorous planning and review, involving an open and informed dialogue with stakeholders and the public, is a key factor in the development of Site remediation work scopes. Such activities were evident during development of the TRU waste remediation effort at SRS, resulting in a savings of $700 million and reducing the projected schedule for completing the SRS TRU waste mission by over 20 years.

Deployment of a "fit-for-purpose" technology within a well-defined and analyzed safety envelope has proven to be cost-effective and actually contributes to project safety over complex remote remediation systems. Investment in the removal of uncertainty in planning of remediation efforts will produce significant returns in cost and schedule savings.

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