TRANSURANIC AND MIXED WASTE FOCUS AREA

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ABSTRACT

On March 26, 1999, the Waste Isolation Pilot Plant (WIPP) received its first shipment of transuranic (TRU) waste and on November 26, 1999, the Hazardous Waste Facility Permit (HWFP) to receive mixed waste at the Waste Isolation Pilot Plant (WIPP), issued by the New Mexico Environment Department, became effective. Facilitating and supporting the disposal of TRU waste became one of the major challenges and opportunities for the Department of Energy's (DOE) Environmental Management (EM) Office of Science and Technology (OST). In August 2000, the Transuranic and Mixed Waste Focus (TMFA) was chartered by the Assistant Secretary for Environmental Management to be co-managed by the DOE's Carlsbad Field Office (CBFO) and the Idaho Operations Office (ID). (1) The new Focus Area will not only maintain support for the mixed low-level waste (LLW) program, but also will enhance the OST's support for the TRU waste program in meeting the challenges of optimizing the TRU waste system.

After WIPP began receiving waste, it was evident that, at the rate at which TRU waste was being shipped to and received at WIPP, the facility was not being used to its full potential, nor would it be unless changes were made. The TRU Waste System needed to be optimized and the newly chartered TMFA is one of the vehicles by which that optimization will occur.

INTRODUCTION AND BACKGROUND

During 1999, the WIPP achieved two significant milestones. The WIPP opened for the permanent disposal of TRU waste resulting from weapons research and production on March 26, 1999; and on November 26, 1999 the HWPF became effective. The WIPP's opening represented the resolution of a number of scientific, engineering, regulatory, and political issues, but was only the first step in a new set of challenges. The requirements of the permit had to be met and TRU waste had to be characterized and certified according to that permit. The result of these requirements was that the number of TRU waste shipments was far below WIPP's design capability. As a result, two major activities were initiated by CBFO: the "Re-engineering Effort to Fill the Pipeline to WIPP" and modifying, through proper channels, the HWFP for efficiency and greater throughput. In the meantime, the National Academy of Sciences (NAS) WIPP Panel had undertaken a study to evaluate the WIPP's characterization and transportation systems. In 1997, the CBFO (the then Carlsbad Area Office) Manager requested that the NAS consider how to assess the performance of WIPP in isolating waste from the environment. Further, the panel was asked to report on the basic minimal requirements

and procedures that should be applied to waste management operations. The NAS has recently published its interim report, "*Improving Operations and Long-Term Safety of the Waste Isolation Plant*," due for final publication in 2001.

The TRU Waste System must be managed as an integrated system among the various DOE TRU waste sites and the WIPP operation. Complex administrative and regulatory requirements for characterization, transportation, and disposal of TRU waste at WIPP are exceptionally costly and onerous to implement. Often these requirements lead to unnecessarily long and inefficient waste handling operations that in turn lead to added risk to workers from exposure to radioactive materials without any commensurate decrease in risk. The TRU Waste Optimization Project (the Project) has been established to find, develop, and implement cost-effective system optimization strategies that will address these issues. For the Project, plans are being prepared that describe the strategy and the implementation of actions being taken or to be taken that resulted from the recommendations of the Re-engineering Effort, the NAS WIPP Panel's interim report, and the systems engineering analysis that will fill the pipeline to WIPP in a safe, efficient, and cost-effective manner. Also taken into account for the optimization is a systems engineering analysis of technology needs that was initiated by CBFO in the spring of 2000 to identify technology gaps in the characterization, transportation, and disposal of TRU waste and to identify and prioritize technology solutions.

As a result of the chartering of the TMFA, CBFO are Partners in the TMFA for Program Direction, Program Integration and Communication, Material Handling and Characterization Product Line Manager, the Non-Thermal Treatment Product Line Manager, and Work Package Managers for the two Product Lines. The Partners are the Project's link to the TMFA.

TRU WASTE SYSTEM OPTIMIZATION PROJECT

Three major areas must be optimized to allow WIPP to operate at its full potential. These areas are in line with the problem areas already identified by the TMFA. They are: 1) characterization of TRU waste, 2) transportation of TRU waste, and 3) disposal of TRU waste at WIPP. The approach of the optimization project is to focus efforts to optimize characterization, transportation, and disposal operations by planning and implementing system operational improvements or administrative change, technology implementation, new technology research and development activities, and efforts to achieve regulatory relief.

The Project is being implemented in three phases. Phase I addresses activities that immediately positively impact filling the TRU waste disposal pipeline during the first one to two years of the Project. The importance of filling the pipeline is driven by DOE's commitment to close RFETS on an accelerated schedule, and DOE's Settlement Agreement with the State of Idaho. The analysis of technology needs to fill the pipeline to WIPP, keep it full in an expeditious and cost-effective manner is a continuous process. Technology needs identified by the TRU waste sites through their Site Technology

Coordination Groups (STCGs) are the bases for the problems described by the TMFA. Phase I activities that will involve the TMFA include:

- Identifying activities that will have an immediate impact on the TRU waste system's ability to ship waste to WIPP at higher rates. These activities will focus on increasing TRU waste shipments to the WIPP waste receipt design capacity of 17 CH TRU waste shipments per week and six RH TRU waste shipments per week.
- Deploying mobile characterization systems (initial stage of the Centralized Characterization Facility (CCF) Project at WIPP) to TRU waste sites to expedite waste characterization and increase shipments toward the design receipt capacity of WIPP, as well as to support the closure of small quantity sites (SQSs). The facility will initially be used to accelerate closure of SQSs by campaigning waste from their respective facilities. It will later evolve to help large TRU waste sites with confirmation disposal characterization activities to enable them to meet compliance orders and State's agreements.
- Identifying (through the STCGs) and prioritizing technology development and science needs.

Research and development for a new technology may take three to five years to develop to the point of demonstration and deployment. Since Phase I covers approximately two years, it is assumed that no new technologies will be developed through the TMFA, but there could be deployment of existing new technologies, using EM-50 programs, e.g., the Accelerated Site Technology Deployment Program.

Phase II further addresses optimization of the TRU waste system after the Phase I objective of filling the pipeline has been achieved. This phase deals with longer-term needs related to TRU waste disposal and evaluation of changes to the system to make it more efficient and cost effective. The focus will be on technology development and deployment while completing the implementation of administrative and regulatory changes. A system model will be used to test the proposed changes to ensure it does not compete with other suggested changes and to ensure that the appropriate scope is encompassed. TMFA involvement with activities in Phase II include:

- Assisting with new needed technologies for the CCF Project.
- Continually evaluating the longer-term needs (>2 years) for the TRU waste system and focusing on changes that make the system more efficient and more cost effective.
- Coordinating administrative/operational efficiencies and regulatory changes with technology development and deployment. Technology will be used to resolve specific needs, reduce operating costs, or as an interim measure to provide a technical basis for implementing regulatory change.

Phase III provides for a longer-range vision of expanding the mission of WIPP to help solve waste management problems of national importance beyond the TRU waste management issues of the current mission (e.g., non-defense sealed sources).

NEW TECHNOLOGY DEVELOPMENT

The TMFA will work closely with the Project so that needed technologies will be available when they are required. Also, the TMFA will assist the Project in deploying useful developed technologies that will help to optimize the TRU waste system efficiently and cost effectively.

The initial technology needs identified through the Re-engineering Effort, the NAS WIPP Panel and the systems engineering process to optimize the TRU waste system are listed below and have been grouped according to characterization, transportation, and disposal headings.

Characterization

TRU waste sites characterize wastes using a combination of acceptable knowledge, destructive analyses, and nondestructive analyses. Acceptable knowledge on the stored waste streams may not provide the detailed data needed to meet current WIPP characterization requirements. Destructive analyses require opening and drawing multiple samples from each container. This increases exposure risks to workers and the environment, and is slow, expensive, and generates secondary waste streams. The TMFA's objective is to improve end-users' capability to nondestructively examine and assay containerized waste for radioactive and hazardous components. (2) Identified characterization needs include:

- Automated Data Review and Validation
  - An electronic data reporting system is needed that will generate WIPP-compliant characterization data packages and also automatically review, verify, validate and reconcile the data quality objectives, quality assurance objectives, quality control criteria, and calibration requirements. The system should also proved the capability to upload required information into the WIPP Waste Information System. Such a system will significantly reduce the cost of generating those data packages needed to certify waste for WIPP and will allow sites to ship waste at higher rates than those currently achievable. An automated data review and validation capability will allow this process to be performed quicker and more accurately than if performed by a person aided by only a spreadsheet (current practice at most sites).
- Centralized TRU Waste Characterization Facility Equipment Development
  - A Centralized Characterization Facility (CCF) located at WIPP is needed as a solution to perform disposal characterization activities on TRU waste from small quantity sites (SQSs). The baseline plan to conduct complete characterization of TRU waste at the individual SQS is inefficient and extremely costly. SQSs do not have the infrastructure to meet the WIPP characterization requirements for certification. The CCF concept will require development and deployment of new or improved characterization technologies to optimize the process. Examples of some additional needs are advanced nondestructive assay (NDA) techniques,

advanced nondestructive examination (NDE) techniques, or alternatives to visual examination (VE).

- NDA for Ten Drum Overpack (also regulatory)
  - The Ten Drum Overpack is currently the largest CH certified container for shipping to WIPP. However, its usefulness is limited because NDA capability for the ten-drum overpack has not been established. Direct packaging provides the opportunity for oversize materials and bulk packaging of up to 20 drum equivalents in one container.
- Develop NDE techniques to analyze shielded and remote-handled (RH) drums (High Intensity real-time radiography (RTR)) for RH and shielded (lead-lined drums)
  - The need is to develop a non-destructive examination system, which can provide the high penetrating power required to interrogate both CH packages and RH shielded packages. Visual examination and repackaging of wastes with high radiation fields is extremely labor intensive with associated increases in worker radiation exposure. For example, CH waste drums containing large amounts of americium are lead-lined in order to reduce exposure. Accordingly, current RTR techniques cannot analyze the content of the lead-lined drums. Similarly, RH waste inserts and casks are too thick for conventional RTR analysis and high radiation levels may further complicate interrogation.
- Mobile treatment of free liquids in sludges, debris and liquid TRU wastes
  - There is a need to develop a mobile treatment process to treat free liquids in sludges, debris, and liquid TRU wastes. A significant portion of sludge wastes at sites cannot be transported or disposed of at WIPP because they contain free liquids. TRU waste should contain as little residual liquid as reasonable but must not exceed 1% volume of the waste container. Most sites within the DOE-EM Complex lack a method for removing waste sludges from a drum in order to add absorbent to take up the free liquid. Because of various restrictions on the sites as well as the cost and time to build a dedicated facility at each applicable site, a mobile treatment process is needed to perform the operations required to solidify free liquids.
- Mobile Treatment system for flammable volatile organic compounds (VOCs) in TRU Waste
  - A mobile treatment process is needed that can remove VOCs via thermal desorption processes. Waste containing VOCs which have a combined vapor concentration exceeding 500 parts per million (ppm) cannot be shipped to WIPP. There is a very large fraction of TRU waste in the DOE-EM Complex that is currently stored and contains significant quantities of flammable VOCs. Most of the sites list a significant fraction of their total TRU waste streams as probably containing VOCs. Mobile treatment by this method can be achieved without having to repackage the waste after treatment.
- Mobile treatment process for "characteristic" hazardous TRU waste
  - Waste destined for WIPP cannot be hazardous in that it must not be ignitable, corrosive, and chemically reactive. Most of the sites within the DOE/EM complex cannot treat wastes to eliminate hazardous characteristics. There is a need to design, develop, and construct mobile treatment processes that can remove waste from a drum, neutralize any corrosive materials, and stabilize any

ignitable and reactive materials by encapsulating the material in an inert material such as cement, and then be able to repackage the stabilized waste.

- Headspace Gas Analysis Improvements
  - A simplified at-drum analysis technique with automated data management is needed. The WIPP Waste Analysis Plan for CH waste contains a number of prescriptive sampling and analysis requirements for head space gas that do not contribute to meeting the required Quality Assurance Objectives. These unnecessary requirements significantly increase the cost and time required for sampling and analysis with resulting increases in worker radiation exposure (an as-low-as-reasonably achievable (ALARA) issue) without significantly lowering risks for disposal at WIPP. Accordingly, alternative headspace gas sample extraction or collection devices with documented performance equivalent to methods currently in use are needed.
- Cargo container counter for screening D&D materials before dismantlement
  - A sealand-type container counter needs to be developed which will provide much lower limits of detection than have been achieved to date. Demolition of buildings at various DOE/EM sites will generate large volumes of wastes (including TRU and low-level). Some of these wastes are to be sent to various sites for disposal depending on the level of radioactivity and whether it is mixed waste. When the radioactivity level is below the regulatory level, the rubble can be left in place or reused for landfill. Therefore, characterization of this D&D waste to satisfy disposal site waste acceptance criteria and to allow for the selection of the least costly approach for disposal has the potential for large cost savings and reduction of worker risk. Sealand-type containers are good candidates for this application. However, NDA counters for cargo containers (8' x 8' x 20') do not exist.
- Mobile treatment of difficult or orphan wastes
  - There is a need to develop approaches for treating waste streams at TRU waste sites that do not have a path forward for disposal, as they cannot be disposed at WIPP. The two most important waste streams in this "orphan" category are wastes containing between 10 nanocuries per gram (nCi/g) and 100 nCi/g plutonium (Pu), and the Pu rich material, i.e. greater than 200 grams per drum or in some cases impure Pu oxide. Blending these two waste streams generates transuranic waste with a viable disposition path from two orphan waste streams.
- Improved techniques for Resource Conservation and Recovery Act (RCRA) metals determination
  - Evaluate characterization techniques to sample RCRA metals in homogeneous waste. Rapid sampling and analysis techniques for RCRA metals are required that will allow an operator to obtain near real-time data on RCRA metal contaminants in sludge and other homogeneous waste streams. The current techniques for sampling RCRA metals in homogeneous wastes are expensive and difficult to perform. The current technique involves obtaining a core sample from the TRU waste drum and then performing the appropriate chemical analysis. Other techniques should be evaluated to provide this rapid sampling and analysis.
- Gate System for TRU and LLW
  - Segregation methods for separating TRU waste and low-level waste are needed. There is no uniform set of standards for segregating these wastes, which has led

sites to create waste categories for which there are no clear disposition paths. Standardized methods with prescribed precision and accuracy are needed to allow for accurate waste type segregation.

- Supercompaction of TRU waste drums
  - By supercompacting TRU waste drums, more drums can be loaded into a Type A container for shipment to WIPP.

Transportation

The Nuclear Regulatory Commission (NRC) has imposed flammable gas concentration limit on TRU waste transported using the TRUPACT-II, HalfPACT and RH 72-B shipping casks, to minimize the potential for loss of containment during transport. Two primary limits imposed by the NRC on the shipping payload are: 1) the concentration of flammable gases (i.e., hydrogen and methane), must not exceed 5 percent (by volume), and 2) the gas phase concentration of flammable volatile organic compounds (VOCs) must be less than 0.05 percent (500 ppm). These limits must be complied with for the 60-day shipping period. Two options are available to sites for solving this problem: gas generation testing on each drum and waste form modification via repackaging and/or treatment. The TMFA objective is to expand the waste payload envelope of transuranic waste transported to WIPP for disposal. Transportation needs include:

- Reduction of Inner Layers of Confinement
  - A technology is needed to rupture all the waste-containing bags within a TRU waste drum. A technology that will reduce the layers of confinement will largely eliminate the need to re-package and/or treat waste to meet TRUPACT-II wattage limits and more waste can be shipped to WIPP.
- Mobile system for RH canister loading
  - Many RH-TRU waste sites need equipment capable of loading and characterizing RH-TRU waste. This proposed technology development activity involves the development of a mobile system of specialized equipment to perform efficient and cost effective packaging of high activity waste in approved RH-TRU canisters. This mobile system must be capable of performing all of the packaging and characterization operations on the canisters in either a horizontal or vertical position in appropriate facilities at the various sites. The resultant packaged canisters will then be acceptable for shipment to the WIPP.
- Shielded Package for RH-TRU waste (Packaging options for RH in CH containers)
  - A shielded package is needed for RH TRU waste. There is currently no way to ensure that all of the RH-TRU waste can be disposed of in the room walls prior to CH emplacement at the current projected CH emplacement rate. To do this it is necessary to have Type A packages that may be used to shield RH waste so it can be handled as CH waste. Alternative RH-TRU waste transportation packages may be required to accelerate shipments of wastes to WIPP in TRUPACT-II's and to maximize the RH disposal capacity at WIPP.
- Improved transportation packages to accommodate waste that is either too large to be shipped or has identified barriers to be shipped

Needs that have been identified that require scientific investigation include:

- Drum corrosion mitigation
  - There is a need for a development of a method to mitigate the corrosion that occurs in waste containing high concentrations of VOCs from hydrochloric acid gas generated from the radiolysis of the VOCs. Corrosion could be mitigated through thermal desorption, in-drum adsorption of acid vapors generated by radiolysis, by coating waste drums with a material inert to acid vapor attack, or by some other passivation technique.
- Gas generation science
  - There is currently no cost-effective method for shipping high-activity Pu-238 waste to WIPP in the TRUPACT-II due to generation of hydrogen gas during transport. Hydrogen gas is generated in Pu-238 CH-TRU waste via radiolysis of paper, plastic, and water contained within waste drums. The scientific basis for understanding hydrogen gas generation in Pu-238-containing wastes is not well understood. Gas generation testing of Pu-238 wastes is needed in order to understand the hydrogen generation rate over time. A detailed chemical model that can accurately predict hydrogen generation rates needs to be developed. Measured gas generation rates should then be correlated with the gas generation rates predicted by the model.

    A second area of study involving gas generation issues in transportation is the use of hydrogen getters to sorb the hydrogen. Research on getters for use in the TRUPACT-II has been ongoing for sometime. A decision must be made on the best getter available for use within the TRUPACT-II. A technical evaluation of available getter materials must be made to define an effective getter. This will lead to a recommendation as to whether getters should be implemented or their further development discontinued.

Disposal

The optimization of the disposal process will be handled mainly through administrative and regulatory modifications for the WIPP facility. However, robotics may help to optimize the disposal operations at WIPP, but there are no technology needs identified for disposal at this time.

Needs developed through the TRU optimization process have been prioritized and will be fed to the TRU and Mixed Waste Focus Area (TMFA) by the Carlsbad Field Office Site Technology and Coordination Group, to continue with the process. The TRU Waste Optimization Project will work closely with the TMFA to track that high-priority technology development needs to more cost effectively and efficiently optimize the TRU waste system.

Over the life of the Project, funding for technology development and R&D could come from a variety of sources including the National TRU Program, TRU waste sites, and the TMFA. The source of funding will depend largely on the time frame for the work. In

most cases, work that must be done within the first two years of the Project will probably be funded by the National TRU Program through the DOE CBFO, or by a site that would directly benefit from deployment of a technology. Funding for technology needs that extend beyond the first two years of the Project will be sought through the TMFA.

CONCLUSION

The opening of WIPP in March 1999 for the disposal of TRU waste offered both opportunities and challenges to the DOE-EM Cleanup Program, technology developers, and users. The establishment of the TMFA is one of the EM efforts to respond to those new challenges and opportunities. The mission of the TMFA is to develop, demonstrate, and deploy technologies to manage and dispose of TRU (mixed and non-mixed) and mixed LLW across the complex.

The overarching need for technology development for TRU optimization is to ensure that technologies are available to efficiently and cost effectively help fill the TRU waste pipeline to WIPP. As such, the recommended technology investments for the Project necessarily span the gap from basic science to deployment of new technologies. The enhanced support for the TRU Waste Program from the TMFA helps the CBFO in the optimization of the TRU waste system. This support allows CBFO to expeditiously fill the pipeline to WIPP by developing new technologies that will have a significant, positive impact on the ability of the TRU waste complex to generate, ship, and dispose waste, and achieve economies, efficiencies, and optimization by deploying new technologies throughout the complex. In summary, the TMFA plays a large part in the optimization of the TRU Waste System.

REFERENCES

1. Letter from Carolyn L. Huntoon to Distribution, "Transuranic and Mixed Waste Focus Area Charter," August 2000
2. Draft "Transuranic and Mixed Waste Focus Area Multi-Year Program Plan FY 2001, (2001)