COMPLEX PROCESS FOR SAMPLING OF DEFENSE PRODUCTION WASTES

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ABSTRACT

Data quality objectives planning processes were conducted for vapor and sludge sampling of the Hanford Plutonium Finishing Plant (PFP) Tank 241-Z-361. The sampling activity resulted from a U.S. Department of Energy (DOE), Richland Operations Office (DOE-RL) "unreviewed safety question" (USQ), related to unquantified hazards and risks tied to tank structural stability, fissile inventory of sludge, and vapor flammability. The characterization process will support the selection of CERCLA remedial alternatives for the tank. Sampling involves three media: sludge, liquids, and, if present, vapors.

Tank 241-Z-361 was constructed of concrete with a partial lining of carbon steel. The dimensions are 7.9 meters long, 4 meters wide, and approximately 5.3 meters deep. The settling tank was used to entrain suspended solids from defense plutonium processing effluents. The tank is thought to contain between 26 and 75 kilograms of plutonium from a "material unaccounted for" source.

The sampling program was developed to support a risk evaluation and determination of the urgency for remediation. The process incorporated the following considerations:

1. Process knowledge was used to identify the fissile isotopes (plutonium, americium, uranium, technetium, neptunium, and strontium) to include in classifications for safety authorizations. Total isotopic inventories, distributions, and concentrations will support criticality evaluations for operations during the remedial action.
2. Volatile and combustible gases were evaluated in Phase I initial vapor sampling. Fugitive release of airborne alpha emitters was monitored and protective engineering controls were used to contain potential releases.
3. Process knowledge identified a number of hydrocarbon contaminants as potential industrial hygiene risks to workers.
4. The retrieved waste will have to either be shipped to the WIPP site as transuranic waste or stored on site. Waste-designation concerns are related to definition of regulatory applicability, disposal acceptance criteria, mixed waste, transportation limits, and transuranic concentrations.
5. Universal treatment standards, pH, carbon content, particle size, chemical compatibility, and vitrification-sensitive analytes will be evaluated to support treatment alternatives by stabilization, vitrification, and packaging.

BACKGROUND

Tank Description

Tank 241-Z-361 is an inactive underground tank within the fenced security area of the PFP (DOE-RL, 1992). This tank received liquid effluents discharged from PFP processes from 1949 through 1973. The function of the tank was to allow solids to settle out of the liquid waste before it was disposed to ground via the underground PFP disposal cribs. Supernate was pumped from the tank and the tank was isolated in 1975. The tank was sealed in 1985 to prevent gas-phase communication with the surface.

Photographs taken in 1975 show that much of the carbon steel liner appeared to have dissolved through corrosion. Although the photographs also showed some degradation of the concrete surface, the exposed concrete appeared to be intact. The condition of the concrete below the waste surface could not be ascertained.

The tank is 7.9 m long and 4 m wide and varies in depth between 5.2 m deep at the inlet (north end) and 5.5 m deep at the outlet. The tank base is 22.9 cm thick with grout and waterproofing added for a total thickness of 30.5 cm. All walls are 30.5 cm thick and the roof is 25 cm thick. The top of the tank was sealed with 64-mm mastic and approximately 10 cm of concrete were poured over the mastic with 5.1 cm by 5.1 cm of 14-gauge reinforcement mesh. The interior of the tank was lined with 1-cm carbon steel on the bottom and up the sides to within 15 cm of the roof. A protective coating was placed between the liner and the concrete as a corrosion barrier.

Tank Contents

Approximately 240 cm of sludge with a volume of about 75 m^3 remains in the tank. It is believed that the sludge is composed of the non-water-soluble components of plutonium production effluents.

The tank is believed to contain between 26 and 75 kg of plutonium (Freeman-Pollard 1994). A 1997 criticality study (Lipke, et al., 1997) concluded that, although the plutonium inventory was potentially sufficient to generate a criticality, its distribution within the sludge makes an inadvertent criticality extremely unlikely.

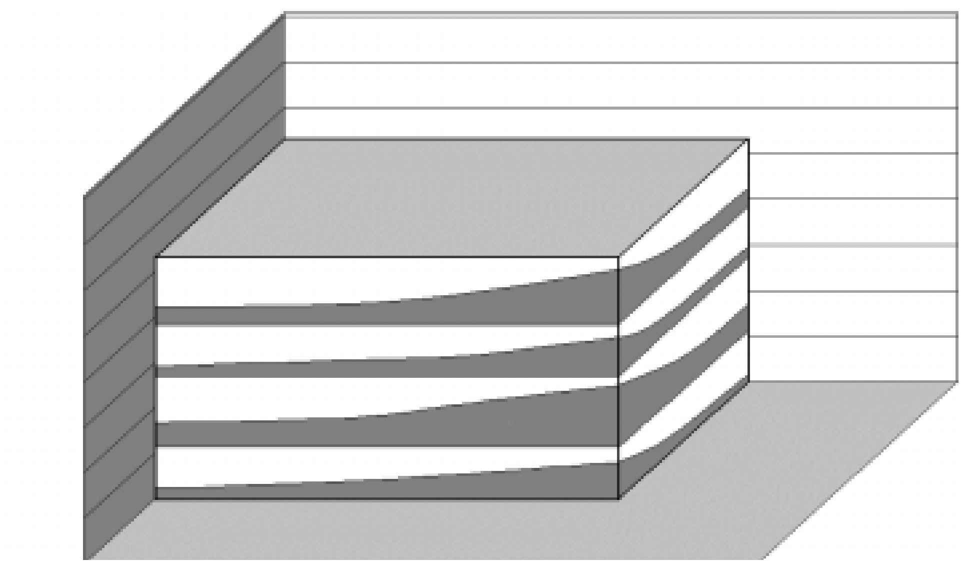
The *241-Z-361 Tank Justification for Continued Operation* (PHMC, 1998) (JCO) authorized a series of activities to define the actual hazards associated with the tank and the collection of data. From a nuclear safety perspective, opening the tank and other intrusive activities constitute "changes in condition" in the safety authorization basis.

Conceptual Model

A single-waste distribution model has been hypothesized for the sludge. A basic assumption is that the sludge is mostly undisturbed, except for the small areas near the risers that have been sampled previously by either core or bottle, or both. It is thought that the undisturbed plutonium salts are distributed in strata which correspond to historical discharge activities.

A distribution of wastes was hypothesized to support the development of the conceptual model. This distribution is illustrated by the cross section shown in Figure 1. The dark layers in Figure 1 represent the heavier plutonium salts that would have settled out of the tank influent first, followed by the lighter salts, which are represented by the light layers in the figure. Because the waste stream entered the tank at a high velocity, the particulates would be transported to the center of the tank before beginning to settle out of the liquids. Therefore, the heavier plutonium salts would have mounded toward the center of the tank. The lighter salts would then have settled out more slowly, accumulating around the perimeter of the mound of plutonium salts and evening out the depth of the overall stratum. Based on discharge records and sample descriptions, between three and twelve strata are thought to be present.

Figure 1. Waste Distribution Model Tank 241-Z-361.



Process knowledge indicates that there would have been low plutonium concentrations in the wastes disposed through the tank and relatively few other radionuclides should be present (PHMC 1999). Limited sampling of the sludge indicates that plutonium is distributed within strata throughout the tank; however, this distribution is somewhat heterogeneous and ill-defined. Because historical sample data were collected over different time periods, it is impossible to determine whether variability is due to time differences, location differences, or a combination of both. An analysis of variance indicated that the differences observed qualitatively are statistically significant. The differences cannot, however, be attributed specifically to either time or location because these factors are confounded. The overall conclusion from the historical data is that the conceptual model is impossible to verify based on available data.

Characterization data are required to evaluate the need for an early removal action and, as required, to determine the appropriate methods for (1) removal of the sludge from Tank 241-Z-361, (2) stabilization and packaging of the waste, and (3) sludge disposal.

Additional data may be required during the implementation of any agreed-upon removal process or to support removal of the sludge in a non-expedited time frame.

Objectives

Tank 241-Z-361 was identified in the *Hanford Federal Facility Agreement and Consent Order* (Ecology, et al., 1994 for remediation under the authority of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The U.S. Environmental Protection Agency (EPA) is the lead regulatory agency for Tank 241-Z-361, identified within the CERCLA (DOE-RL 1992).

A chemical hazard assessment (FDNW, 1997) identified potential hazards associated with Tank 241-Z-361. These hazards were not completely evaluated and controlled within the current Plutonium Finishing Plant (PFP) nuclear safety authorization basis. Potential hazards included flammable gas accumulation within the tank, inadvertent criticality, and degradation of the structural integrity due to corrosion of the concrete and reinforcing bars. DOE declared an nuclear unreviewed safety question (USQ; Wagoner, 1997) for the tank based on the potential for flammable gas accumulation, unevaluated structural concerns, and the possibility of criticality concerns changing with time. The contents of Tank 241-Z-361 must be characterized to determine whether it is necessary to remove the sludge to resolve safety, safeguards, and environmental issues. Interim safety controls were imposed, which restricted spark- and flame-producing activities in the vicinity of the tank and which prevented vehicle traffic over the tank.

Consequently, two EPA data quality objective (DQO; EPA, 1994) processes (*Tank 241-Z-361 Waste Characterization Data Quality Objective: Headspace Vapor and Tank Structure*, Field, J. G. and D. L. Banning, LMHC, and Environmental Quality Management, 1998; and *Tank 241-Z-361 Sludge Characterization Data Quality Objectives*, BWHC, 1999a) were conducted for the initial, safe collection of data and for planning potential subsequent activities. The EPA DQO process and the DOE nuclear safety justification for continued operation (JCO, PHMC, 1998) were used to develop activity-specific data needs and planning for safety. The DQO process incorporated the concerns of the USEPA and DOE, as well as Washington Department of Ecology and the Washington Department of Health.

Results of Tank 241-Z-361 sampling and analysis will determine whether expedited response actions are required because of the hazards associated with tank contents. New data will be used on an ongoing basis to select subsequent appropriate actions.

This paper focuses on the development of the rationale for sampling and analysis to support numerous requirements and needs. The paper does not list all of the analytes and analytical constraints.

DATA COLLECTION STRATEGY

Data were collected in a phased approach to characterize the contents of the tank. Phase I included a characterization of the head-space air in the tank and evaluation of the tank integrity. Phase II was designed to provide an assessment of the sludge within the tank to evaluate its content, the risk associated with the sludge, and the need for an early removal. A DQO process was followed for each of these activities to determine the goals for the sampling programs.

The DQO process is a systematic process for managing uncertainty and to comprehensively identify data needs, as outlined below:

1. State the Problem
2. Identify the decision(s)
3. Identify the inputs to the decision(s)
4. Define the study boundaries
5. Develop decision rules or decision logic
6. Specify acceptable limits on decision errors
7. Optimize the design.

The organizations listed below were involved in the development of the two supporting DQO processes:

- DOE-RL Facility Transition group oversaw the prime contractor activities.
- Fluor Hanford, as the prime contractor, provided oversight.
- The B&W Hanford PFP Transition Engineering team provided the primary management of the DQO process and development of the sampling and analysis plans (SAPs).
- Lockheed Martin Hanford Corporation, Tank Waste Remediation System (TWRS), supplied expertise for opening tanks, working around potentially explosive gases, and sampling of high-activity radioactive waste.
- Lockheed Martin Hanford Corporation, TWRS, Process Engineering supplied additional expertise related to coordination with a hot cell laboratory.
- Project Enhancement Inc. provided engineering and nuclear safety inputs.
- Environmental Quality Management, Inc. provided facilitative and technical support with the DQO processes and sampling/analysis plans.
- Numatec Hanford Corporation, Special Analytical Support, assisted with analysis of vapor samples.
- The USEPA was the lead agency for implementation of the CERCLA process. EPA coordinated with the Washington Departments of Ecology and Health to evaluate and incorporate their concerns.
- Waste Management Hanford supplied analysis of samples.

Phase I - Summary of Planned Activities

Phase I of the JCO provides a safety basis and describes the operations and controls for opening the tank safely, resolving structural integrity and flammable gas issues, and generally assessing the condition of the tank contents. Phase I is addressed in the Vapor SAP (Hill, et al., 1998) and included the following activities:

- Riser and work-area preparation, replacement of the riser bolts with non-sparking bolts.
- Installation of a glovebag containment around the riser. A breather filter on the riser permitted passive ventilation of the tank; the filter assembly included a vapor sampling port.

- Venting excess pressure, while maintaining a non-flammable atmosphere within the glovebag. The glovebag design provided for active purging using an inert gas.
- Installation of an integral vapor sampling port in the breather filter to enable the collection of tank-dome-space vapor samples without the need for additional containment.
- Collecting and analyzing representative interior tank-vapor samples from the head space for chemical analysis.
- Videography of the interior of the tank to enable engineering evaluation of the physical condition of the tank and answer structural integrity questions.

Successful completion of the Phase I activities will support future sludge waste sampling (Phase II) and CERCLA tank closure activities.

Phase II - Summary Of Planned Activities

Phase II activities consist of sludge sampling and characterization, as described in the Sludge SAP (BWHC, 1999b). The process included an evaluation of historical documents to describe the waste streams discharged to the tank. The sampling approach included the collection of two, full-thickness push cores. The Sludge SAP (BWHC, 1999b) detailed the approach for organic analyses.

Successful completion of the activities described in the SAP will support future waste treatment and tank closure activities. Sampling will support the following data needs:

- Characterize the waste for the determination of criticality, chemical, and safeguard concerns, as expressed in the USQ report;
- Estimate the near-term or long-term stability of the tank contents; and
- Evaluate remedial (retrieval, treatment, and disposal) alternatives.

<u>CERCLA Early Removal Decision.</u> Phase II data will be evaluated to determine whether a CERCLA early removal action is needed. Considerations for early removal include tank instability, criticality, chemical hazards, and safeguards. Preliminary assessments indicate that early removal of the sludge may be warranted due to potential risks to human health and the environment. Additional characterization data are necessary to more fully assess the need for an early removal. ARARs for the sludge removal include characterization and handling of the waste under RCRA and control of nonradiological and radiological air pollutants and TAPs emissions under the *Clean Air Act of 1990*.

<u>Retrieval, Treatment, and Disposal Decisions</u>. Characterization must provide sufficient data to support a decision as to the most appropriate method(s) from both the physical and regulatory perspectives for retrieval, packaging, and disposal of the sludge. These data must support the following characterization requirements:

1. Describe the physical composition of the sludge, which will help in evaluating retrieval alternatives;

2. Define the chemical composition, to support an evaluation of the disposal and packaging alternatives; and
3. Provide sufficient data to allow the waste to meet acceptance criteria.

PROBLEM STATEMENTS

The DQO problem statements define the objectives to be addressed by data collection. Table 1 presents the problem statements for Phase I and Phase II activities.

Table 1. DQO Problem Statements for Investigation of Tank 241-Z-361

Phase I (see, Field & Banning, 1998):
• The need for off-gas controls to meet applicable environmental regulations during tank core sampling in Phase II must be determined.
• Controls on headspace vapors to ensure worker safety during core sampling and remediation of the waste in Phase II must be determined.
• The need for engineering structures (e.g., truck ramps or bridges) during core sampling to support the load of core sampling equipment must be evaluated.
Phase II (see, BWHC, 1999b)
• Existing characterization information indicates a potential need for an early CERCLA removal action; however, available data are limited and don not reflect current conditions.
• Insufficient data are available to determine whether a criticality, chemical, or safeguards concern could arise during remedial actions.
• Sufficient characterization data are not available to ensure worker safety during remedial actions.
• Available data are not adequate to assess early retrieval, treatment, and disposal options.

Treatment and Disposal Alternatives. Disposal options include separation and shipment of non-transuranic (TRU) constituents to the Hanford Environmental Restoration Disposal Facility (ERDF) and TRU wastes to the Waste Isolation Pilot Plant (WIPP) in New Mexico. Characterization must provide sufficient definition of the sludge to support analysis of constituents against the waste acceptance criteria (BHI, 1998 and DOE, 1996) for these facilities. Preliminary alternatives for management of the sludge (see Table 2) are divided into approaches for removal of the sludge from the tank and approaches to storage and/or disposal of the sludge after removal.

Table 2. Preliminary Sludge Removal and Management Alternatives

Preliminary Sludge Removal Alternatives	Preliminary Alternatives for Sludge Management
• In-situ vitrification • Remove Sludge from tank by sluicing, and store or dispose of waste. • Mechanically remove sludge from tank and store or dispose of waste.	• Sluice sludge to Tank Farms for ultimate vitrification with high level wastes. • Package the waste and dispose to WIPP. • Package the waste for interim storage with other TRU wastes at Hanford.

The WIPP is concerned primarily with the radionuclide content of the individual waste packages. Although the WIPP will not reject waste based on land disposal restrictions (LDRs) or other *Resource Conservation and Recovery Act of 1976* (RCRA) limits, the waste must be characterized to identify relevant RCRA characteristics and waste codes. LDR limits are a concern, however, if waste is to be shipped to the ERDF. Radionuclide content also must meet ERDF waste acceptance criteria.

In addition, characterization must describe physical parameters, such as particle size and distribution, to support decisions for sludge removal, treatment, and packaging. LDR and listed waste issues also must be considered as applicable or relevant and appropriate requirement (ARARs) under CERCLA in order to support the site record of decision

DECISION RULES

Decision rules identify how decisions will be made when information becomes available. “If…, then...” statements are constructed to guide data collection and evaluation. The Phase I and II decision rules are summarized in Table 3. The DQO and SAP documents for vapor and sludge sampling provide additional detail and language to support the decision rules.

Table 3. Decision Rules

Phase I
• If the results of vapor sampling indicate that air emissions (TAPs) criteria are exceeded, then additional precautions (i.e., filtering or treatment of vapor) may be required before core sampling or disposition of the waste can occur
• If tank videos and/or photographs indicate the tank steel and concrete may have degraded, such that the structure is weakened, then an evaluation will be made to determine (1) if ultrasound testing is required, and (2) if a bridge should be constructed over the tank to support equipment during Phase II of the characterization program.
Phase II
• If the data indicate a potential hazard, the sludge will be removed from the tank under CERCLA authority for each removal. This decision will be based on considerations of tank stability, criticality, and concentrations of hazardous constituents.
• If the inventory of the tank presents a concern because of potential criticality, chemical hazard, or safeguards issues associated with the removal, treatment, or disposal processes, then procedures will be implemented to mitigate potential hazards and to properly manage identified concerns.
• If sludge analysis indicates unexpected concerns based on potential radiation levels or chemical exposures, then industrial hygiene and health physics procedures will be adjusted to ensure worker safety.
• If Washington State "Dangerous Waste" (hazardous) limits are exceeded, including requirements for corrosivity or reactivity, then the waste can not be disposed of at ERDF without additional treatment.
• If the fissile material levels in the sludge suggest that the Transuranic Package Transporter II (TRUPACT-II) Requirements (DOE, 1998) fissile gram equivalent quantity limits for shipment (DOE, 1998) will be exceeded, then the removal and treatment process will be adjusted to ensure that shipping criteria are met.
• If the analysis for total cyanide or for the determination of total sulfides results in a concentration above the regulatory requirements (250 ppm reactive cyanide, 500 ppm reactive sulfide), then a method will be developed that measures reactive cyanide and reactive sulfide.

INPUTS

Table 4 identifies the key inputs for physical and chemical parameters and regulatory criteria required to support the decisions identified earlier.

Table 4 Decision Inputs

Decision(s)	Input
Phase I	
Determine if a significant hazard of flammability/ explosivity from hydrogen gas is present. Determine potential for chemical gas exposures to occupational workers. Determine if air releases are a hazard that needs to be controlled.	• Headspace gas analysis • Determination of LFLs • Determination of pressurization • $CC1_4$, NO_x, Tri-butyl phosphate, Di-butyl phosphate, acetic acid, benzene, n-butanol • Vapor space: LFL, N_2O, O_2, NH_3, CH_4, H_2 • Toxicity: Benzene, $CC1_4$, NO_2, NH_3
Determine the structural condition of the tank and what protective measures are necessary for sludge sample collection.	• Weight load testing • Tank photographs and/or videos: all tank wall surfaces above the current waste level, ceiling surface, interior surface of risers to be sampled and concrete ceiling at the riser/concrete interfaces
Phase II	
Determine whether an early CERCLA removal action is required. Considerations for early removal include, but are not limited to, tank instability, criticality, chemical hazards and safeguards and security issues.	• Concentration of TRU material • The ratio of TRU material to neutron absorbers • Radionuclide geometry/distribution and water content of the sludge • The presence and concentrations of neutron absorbers (total uranium, iron, nickel, chromium, aluminum, and zirconium) in the sludge • The nature and concentrations of chemical constituents in the sludge
Determine whether the inventory poses a potential criticality, chemical, or safeguards issue during removal or treatment.	• Concentration of TRU material • Ratio of TRU material to neutron absorbers • Radionuclide geometry and water content of the sludge • Compounds in sludge that create chemical reactions • Safeguards category

Determine the precautions necessary to ensure worker safety during removal and disposal, based on sludge characterization.	• Activity levels: total beta, total alpha • Flammable gas levels in the tank headspace • Nature and concentrations of chemical constituents • OSHA/DOE safety requirements
Determine the set of viable alternatives for sludge retrieval, treatment, and disposal based on characterization data.	• Plutonium content (weight percent) • TRU content (plutonium, americium) • pH • Percent moisture • Alkalinity • Specific conductance • Particle size/distribution • Whole rock analysis • Salts • RCRA constituent concentrations
Regulatory Criteria	• RCRA – LDR Limits • ERDF Waste Acceptance Criteria • WIPP Waste Acceptance Criteria • USDOT Transportation Regulations • RCRA Waste Codes • TSCA – PCB Limits

Inputs Considered and Excluded

Several potential areas of regulatory authority were considered as ARARs and determined to be not relevant for this project.

<u>Toxic Air Pollutants/Hazardous Air Pollutants</u>. Process knowledge and data from Phase I sampling indicates that the concentrations of regulated air pollutants will be well below regulatory levels of concern in Phase I. Additional vapor samples will be collected and analyzed during Phase II as a precaution. If the results of these vapor samples indicate a basis for concern over air emissions during remediation, air pollutants will be reevaluated.

<u>Dangerous Waste Characteristics.</u> The waste is not expected to exhibit dangerous waste characteristics of ignitability, corrosivity, or reactivity. Due to potential hazards from igniting plutonium waste and the increased chance of human exposure and laboratory hood contamination, the ignitability test will not be performed on the sludge or supernate.

ANALYTE SELECTION

Historical information was used as a basis to select analytes. One hundred and nine regulated compounds were compared against the compounds from the toxic characteristics, underlying hazardous constituent (UHC), and universal treatment standard (UTS) lists. This comparison identified 86 compounds that are not regulated under UHC or UTS, leaving 23 compounds for further evaluation.

The next step was to consider the process environment for the compounds and how they were transferred to the tank. Waste transfer occurred via jet steaming; it is very likely that highly volatile organic compounds were lost during transfer. Less volatile compounds and volatile compounds that are heavier than water could remain in the tank sludge. Analyte lists were developed for chemical volatiles in the headspace, volatiles in sludge, volatiles in the supernate, and semivolatiles in sludge.

Twenty-two compounds remained from the analyte-selection logic. Analytical parameters required to evaluate for RCRA characteristics, to meet WIPP waste acceptance criteria, health and safety criteria and required radionuclide and physical parameters, were added to create the complete list of COPCs.

Physical properties of the waste, for example, particle size, particle size distribution, pH, percent moisture, and specific gravity were added to support retrieval and treatment process evaluation.

Health and Safety. The Phase I Health and Safety plan (Miller et al. 1998, Appendix C) requires analyses for seven volatile compounds. If any of these compounds are detected during the vapor sampling, then the detected compound will be added to the final list of COPCs and will be analyzed for in the sludge sample.

All field activities will be accomplished with continuous health physics and industrial hygiene support. Radiological monitoring of surfaces and workplace air will be performed using alpha and beta/gamma survey instruments. Industrial hygiene staff will use a combustible gas meter to monitor the workspace and tank headspace for combustible gases. Draeger tubes will be used to monitor carbon tetrachloride.

Criticality/Nuclear Safety. Thirteen radionuclides and parameters were added to support criticality evaluation and worker safety.

Reactivity. The tank sludge and tank supernate will be evaluated for reactivity. This procedure requires analysis for reactive cyanide and reactive sulfide; however, these methods are sensitive to concentrations of hydroxide, which exist in large amounts in Hanford site tanks. The waste will be analyzed for total cyanide, total sulfur, and sulfate.

Waste Treatment. Because vitrification has been proposed as a treatment option, the major element compounds (whole rock analysis) and parameters were added to the list of COPCs, in addition to nitrate and carbon. The whole rock analysis is a geological type of analysis of the oxide concentrations for a range of metals. It is used to assess the potential for vitrification The WIPP waste acceptance criteria (DOE, 1996) requires PCB content of less than 50 ppm. PCBs will be analyzed due to existing uncertainties concerning their presence. The WIPP waste acceptance criteria also include analysis for isomers of xylene. Total xylene analysis of headspace gases and supernate is already being conducted to meet other regulatory requirements. If the total xylene analysis indicates levels of concern, analysis will be performed for the individual isomers.

Radiation Release and Screening. Radiological screening of samples will be performed twice. The first screening will be at the tank riser. Tank Waste Remediation System, Characterization Project, Radiological Control organization will release the canisters, sorbent tubes, sorbent trains, and particulate filters from the job site by direct measurement and smearing. The second evaluation will be the analysis of the particulate filters by Waste Sampling and Characterization Facility for total alpha and total beta.

TOLERABLE LIMITS ON DECISION ERRORS

Phase I

No historical vapor sample information is available for this tank. Consequently, uncertainty estimates are not available to provide a statistical basis for the number of samples needed. Due to the extensive time the tank has remained sealed and undisturbed, it is assumed that the headspace vapor composition will be uniform throughout the tank. Therefore, one vapor sample set will be obtained from one riser. No further statistical analysis of uncertainty parameters will be performed.

Uncertainty questions are not applicable to tank structure assessments. Calculations/ assessments will be updated and added to existing data (including load-test results) based on videography to estimate the tank structure load capacity. The load capacity must provide a safety factor of at least 2 over the load of the sample truck (Field and Banning 1998). If the calculated load capacity is less, engineering controls (e.g., truck ramps or bridge structures) will be designed and constructed before core sampling.

Phase II

Historical data that provide reasonable estimates of variability and tolerable limits on decision errors are required in order to develop a statistical sampling approach. The available historical data do not have the required data quality to support the decisions for this project. Therefore, they will not be used to calculate a number of samples required for a statistically-based design. Statistical sampling designs can also be based on the random selection of sample locations. Random selection is not possible, however, because the sampling locations available are limited to the locations of the risers.

Therefore, the sampling design will not be statistically based. Once the data are collected, however, the degree to which the conceptual model is supported by the data can be assessed and summary statistics and confidence intervals or other statistics may be calculated to support the expedited action, criticality, and worker safety decisions.

There are two types of decision error associated with hypothesis testing. One is mistakenly concluding that the action limits have been met; the other is mistakenly concluding that the action limits have not been met. One must evaluate the consequences of these errors to determine the null hypothesis and tolerable decision errors.
Mistakenly concluding that the action limits have been met is, in other words, deciding that the sludge is "acceptable," when, in fact, it is not acceptable. The target error rate for this was set at 10%. Mistakenly concluding that the action limits have not been met is the converse position. The target error rate for this decision error was 20%. Specific errors associated with each of the decisions, their associated consequences, and the relative severity of those consequences were estimated.

OPTIMIZATION OF SAMPLING AND ANALYSIS DESIGN

Information generated during the previous steps of the DQO process was used to come up with optimal designs for conducting the Phase I and Phase II sample programs.

Phase I Optimization

Data generation to help resolve flammable gas, tank structural integrity, and potential chemical emissions issues was accomplished through the following design:

- **Open tank riser**. The riser flange was opened in a controlled manner, within glove-bag containment, allowing any tank pressure to be released. Controls were in place to limit gas flow and to purge the glove-bag containment if the %LFL exceeded 25%.

- **Install breather filter**. A breather filter on the riser permitted passive ventilation of the tank and included a vapor sampling port. Glovebag containment was kept below 25%LFL throughout the filter-installation activities.

- **Take vapor samples**. Vapor samples were collected via the breather filter vapor sampling port using SUMMA® canisters, sorbent tubes, and sorbent trains.

- **Videotape tank interior**. Camera equipment was lowered into the tank dome space to videotape the interior tank and waste surfaces.

Phase II Optimization

Based on the available information on the internal configuration of Tank 241-Z-361, the Phase II sludge characterization included the following activities:

1. Collect a minimum of one full depth core sample from Riser E, located in the approximate center of the tank, and riser F, located northeast of the central manhole.

2. Supplement the full depth core samples with non-destructive analysis in dry wells that are in an acceptable condition for insertion of down-hole probes.

The decision to collect more data in the immediate future will be based on the level of confidence in the concentration and distribution of radionuclides in the sludge provided by the Phase II characterization. The logic behind this decision is that the primary environmental and safety issue for the contents of Tank 241-Z-361 is resolution of the concern for the potential for a criticality event related to the tank contents. Other issues (e.g., hazardous waste characteristics, and the presence of hazardous waste constituents) are secondary to the criticality assessment. Supplemental data needs related to these other issues could reasonably be filled at a later date (e.g., during actual removal of the sludge from the tank).

The sludge will be cored to the bottom of the tank or to refusal. Previous sampling indicated that the sludge had a consistency similar to peanut butter; therefore, it is unlikely refusal will occur before reaching the tank bottom.

BWHC has identified several down-hole logging techniques that are directly applicable to examination of Tank 241-Z-361:

1. Passive Gamma Logging can detect low concentrations of plutonium-239 and americium-241.

2. Thermal Neutron Capture Gamma Logging can detect and quantify several elements of interest, including hydrogen, nitrogen, aluminum, iron, calcium, sodium, chlorine, cadmium, and plutonium.

3. Neutron-Neutron Moisture Logging can quantify moisture content of the sludge.

By collecting logging data in a series of small depth increments, a relatively high-resolution profile of sludge characteristics may be generated using a combination of all three available down-hole techniques. The ability to apply these tools to Tank 241-Z-361 will be confirmed after the risers are opened and inspected. The requirements for application of the down-hole techniques are as follows:

1. The pipes must be clean and dry and closed at the bottom; and
2. The pipes must have an inside diameter of at least 10.16 cm (4 in.).

Combined with at least one full-depth core sample, this approach should provide a higher confidence in the description of the nature and distribution of critical constituents within the sludge than the collection of a smaller number of full-thickness core samples.

Initial Alpha, Tank Headspace, and Volatile Analyses of Sludge and Supernate

Strata within the sludge samples were established by visual observation in the laboratory. Two subsamples from each stratum were collected for total alpha analysis. The total alpha result will be used to determine whether significant TRU material exists in any given stratum and to answer the USQ (Wagoner,1997). The information also was used to guide compositing of the visual strata for subsequent additional radiological and non-radiological analyses.

Tank vapor samples were collected from two sampling events: (1) the initial opening of the tank, described in the Hill et al. (1998), and (2) during the core sampling process. Volatile headspace analysis was performed of aliquots from any visible stratum that appeared oily or likely to contain organics. In addition to the volatile analysis of the sludge samples, volatile headspace analyses was performed on one supernate sample from each core, for a total of two headspace analyses.

CONCLUSION

Data were generated through Phase I sample collection to evaluate the necessary precautions for the collection of sludge cores from Tank 241-Z-361. Cores were collected in Phase II and are currently being analyzed and the data evaluated. Upon completion of the analysis of Phase II results, the decision-makers will determine the most appropriate method and schedule for the removal of sludge from tank 241-Z-361.

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