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Revision 7

Technology and Innovation Roadmap

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TECHNOLOGY and INNOVATION ROADMAP

RTW PTW DTW

CHIEF TECHNOLOGY OFFICE

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Executive Summary

This Technology and Innovation Roadmap (Roadmap) presents a comprehensive and integrated assessment of the technology elements related to maintaining the River Protection Project (RPP) baseline, reducing risk, and providing opportunity for improvement. These elements contribute to achieving successful completion of the Hanford Site tank waste cleanup mission. Key near-term U.S. Department of Energy (DOE), Office of River Protection (ORP) RPP mission needs with respect to the next 5 years are identified and prioritized. This Roadmap is used to assist with planning near-term scope to address technology development priorities in fiscal year 2023 (FY23).

The Roadmap is updated annually with input from several key sources including DOE, Tank Operations Contractor (TOC) Washington River Protection Solutions LLC (WRPS) management, Waste Treatment and Immobilization Plant contractors, Plateau Remediation contractors, and other knowledgeable fieldwork specialists. All the known technology elements are identified by the appropriate fieldwork specialists and summarized via individual Technology Element Description Summary Sheets (TEDS).

There are over 100 technologies detailed in the Roadmap. The Chief Technology Office (CTO) assigned importance to TEDS based on the communicated focus of the ORP and the RPP mission support needs in the End-State Technology Maturation and Execution (TM&E) chart as well as the Near-Term TM&E Chart. Catalog sheets are then developed to summarize each technology element. The Roadmap is compiled and released for use within the DOE complex. The appropriate representatives then determine the utilization of resources to achieve needed technologies.

TM&E activities are identified to aid the integration of RPP mission programs and support achievement of RPP mission needs. Currently, those activities are categorized into eight mission programs divided into two areas:

1. Direct-Feed Low-Activity Waste Operations Support
    - Immobilized Low-Activity Waste Glass
    - Tank-Side Cesium Removal & Low-Activity Waste Pretreatment System
    - Cementitious Waste Forms
    - Supplemental Low-Activity Waste
2. RPP Mission Support
    - Alternate Retrieval Technology Identification and Development
    - Tank Integrity Technology Identification and Development
    - Sampling & Monitoring Technology Identification and Development
    - Worker Protection (Sampling & Monitoring, Personal Protective Equipment (PPE), Investigation, etc)

As the mission evolves, the programs detailed in the TM&E charts will evolve to address new and emerging needs. Technology elements that align best with the focus of ORP and support the mission needs per the TM&E chart are emphasized as potential solutions to the significant technical challenges facing the tank waste cleanup mission and enhance the safety of the workforce. The information presented in this Roadmap is used to guide investments to address the high priority technical needs supporting the RPP mission and to affect change as necessary.

Scheduling and mission impacts for technology elements in this Roadmap revision are mapped in the End State TM&E chart for the complete mission and the Near Term TM&E chart for the next 5 years. The charts also identify the benefits and risk mitigation potential for non-baseline technologies. Finally, the TM&E charts have the key mission decision points identified. In addition, a National Laboratory Technology Capabilities Matrix is included in APPENDIX F as Table F-1. Roadmap TEDS sheets that identify the need for National Laboratory support are cross walked to National Laboratory capabilities.

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AI	Artificial Intelligence
ALARA	As Low As Reasonably Achievable
ASCEM	Advanced Simulation Capability for Environmental Management
ASME	American Society of Mechanical Engineers
BBI	Best-Basis Inventory
CAM	Continuous Air Monitor
CCN	Cloud Condensation Nuclei
CD	Critical Decision
CEM	Continuous Emissions Monitor
CFD	Computational Fluid Dynamics
CH	Contact-Handled
COC	Compound Of Concern
COPC	Chemical Of Potential Concern
CP	Central Plateau Contractor
CPC	Central Plateau Cleanup Company
CST	Crystalline Silicotitanate
CTF	Cold Test Facility
CTO	Chief Technology Office
DFAS	Data Fusion and Advisory System
DFHLW	Direct-Feed High-Level Waste
DFLAW	Direct-Feed Low-Activity Waste
DOE	U.S. Department of Energy
DOT	Department of Transportation
DST	Double-Shell Tank
DTW	Dispose Tank Waste
Ecology	Washington State Department of Ecology
EM	U.S. Department of Energy, Office of Environmental Management
EMAT	Electromagnetic Acoustic Transducer
EMF	Effluent Management Facility
EOI	Expression of Interest
EPA	U.S. Environmental Protection Agency
EROMS	Enterprise Risk and Opportunity Management System
ERSS	Extended Reach Sluicing System
ESP	Electrical Safety Program
ETF	Effluent Treatment Facility
FFRDC	Federally Funded Research Development
FID	Flame Ionization Detection
FLTF	Field Lysimeter Test Facility
FT	Flash Thermography
FTIR	Fourier Transform Infrared
FWF	Federal Waste Facility
FY	Fiscal Year
GC	Grand Challenge
GC-FID	Gas Chromatography Flame Ionization Detection
GC-MS	Gas Chromatography Mass Spectrometry
GEIT	General Electric Inspection Technology
GPS	Global Positioning System
GWPA	Guided Wave Phased Array
HIHTL	Hose-In-Hose Transfer Line
HLW	High-Level Waste
HWEE	Hanford Waste End Effector
IDAV	Internal Data Access And Visualization
IDF	Integrated Disposal Facility
IEWO	Inter-Entity Work Order
IH	Industrial Hygiene

List of Terms

IHLW	Immobilized High-Level Waste
ILAW	Immobilized Low-Activity Waste
IX	Ion Exchange
LAW	Low-Activity Waste
LAWPS	Low-Activity Waste Pretreatment System
LCO	Limiting Condition of Operation
LDP	Leak Detection Pit
LERF	Liquid Effluent Retention Facility
LIBS	Laser-Induced Breakdown Spectroscopy
LIDAR	Light Detection And Ranging
LLW	Low-Level Waste
LOW	Liquid Observation Well
LSW	Liquid Secondary Waste
LTA	Less Than Adequate
MARS-V	Mobile Arm Retrieval System, Vacuum-mode
MTW	Manage Tank Waste
MW	Manage Waste
MWGS	Mechanical Waste Gathering System
N	No
N/A	Not Applicable
NDE	Non-Destructive Examination
NDMA	N-Nitrosodimethylamine
NEMA	National Electrical Manufacturers Association
NRT	Neutron Radiographic Testing
OEL	Occupational Exposure Limit
OP-FTIR	Open Path Fourier Transform Infrared
ORP	U.S. Department of Energy, Office of River Protection
ORSS	Off-Riser Sampler System
OTS	Operator Training Simulator
PA	Performance Assessment
PNNL	Pacific Northwest National Laboratory
PPE	Personal Protective Equipment
PTR-MS	Proton Transfer Reaction – Mass Spectrometer
PTW	Process Tank Waste
RCRA	Resource Conservation and Recovery Act of 1976
Risk Registry	Enterprise Risk and Opportunity Management Program
Roadmap	Technology and Innovation Roadmap
ROI	Return On Investment
RPP	River Protection Project
RTW	Retrieve Tank Waste
RVMS	Residual Volume Measuring System
SBS	Submerged Bed Scrubber
SCBA	Self-Contained Breathing Apparatus
SLAW	Supplemental Low-Activity Waste
SPP	Strategic Partnership Program
sRF	Spherical Resorcinol Formaldehyde
SRNL	Savannah River National Laboratory
SST	Single-Shell Tank
SSW	Secondary Solid Waste
SWITS	Solid Waste Information and Tracking System
TBD	To Be Determined
TBI	Test Bed Initiative
TEDS	Technology Element Description Summary
TEM	Transmission Electron Microscope
TFF	Tank Farm Fugitive

List of Terms

TM&E	Technology Maturation and Execution
TOC	Tank Operations Contractor
TRA	Technology Readiness Assessment
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989)
TRL	Technology Readiness Level
TRU	Transuranic
TSCR	Tank-Side Cesium Removal
TSR	Technical Safety Requirement
TWCS	Tank Waste Characterization and Staging
TWINS	Tank Waste Information Network System
UT	Ultrasonic Testing
UV	Ultraviolet
UV-DOAS	Ultraviolet Differential Optical Adsorption Spectroscopy
UV-FTIR	Ultraviolet Fourier Transform Infrared] Stack Monitor
VMC&R	Vapor, Monitoring, Characterization and Remediation
VMDS	Vapor Monitoring and Detection System
VOC	Volatile Organic Chemical
VWB	Virtual Workbench
WAC	Waste Acceptance Criteria
WBS	Work Breakdown Structure
WCS	Waste Control Specialists
WESP	Wet Electrostatic Precipitator
WFD	Waste Feed Delivery
WFE	Wiped Film Evaporator
WIPP	Waste Isolation Pilot Plant
WMA	Waste Management Area
WMIS	Waste Management Information System
WRPS	Washington River Protection Solutions, LLC
WTP	Waste Treatment and Immobilization Plant
XRID	X-Ray Diffraction
Y	Yes

1.0 INTRODUCTION

On March 18, 2008, the U.S Department of Energy (DOE), Office of Environmental Management (EM) introduced the Engineering and Technology Roadmap to support the complex cleanup effort. The National Academy of Sciences reviewed the EM Engineering and Technology Roadmap and issued report *Advice on the Department of Energy's Cleanup Technology Roadmap: Gaps and Bridges* (NAS 2009) documenting their gap analysis on the current state of the DOE Hanford Site cleanup effort.

The initial TOC Technology and Innovation Roadmap (Roadmap) was released in 2010 in response to the 2009 National Academy of Sciences report and aligned with the desires and goals of the DOE EM at that time. The Roadmap has been updated and improved with each revision. See APPENDIX A for Tank Farm background information and APPENDIX B for a more complete description of the evolution of the Roadmap.

This edition of the Roadmap is focused on highlighting the technology needs of the Hanford mission for FY22 and FY23 as well as longer term future planning. These needs are identified in individual TEDS sheets and are concisely summarized in one or two pages, known as "Catalog Sheets," See Section 4.0 for more details on TEDS and Catalog Sheets.

There are 103 technology needs highlighted herein. The technologies are summarized by functional area in Table 1-1. The five functional areas are Manage Tank Waste (MTW), Retrieve Tank Waste (RTW), Process Tank Waste (PTW), Dispose Tank Waste (DTW), and Manage Waste (MW).

Table 1-1. Technologies by Functional Area.

Functional Area	Near-Term	Future Projects	Total
MTW	11	29	40
RTW	5	26	31
PTW	4	13	17
MW	1	4	5
DTW	4	6	10
Total	26	77	103

The reduction of the number of technology needs from those reported in the previous Roadmap revision was due to the retirement of several TEDS. Retirements are driven by development work completion and/or recognition of the lack of the technology need or viability and are discussed in APPENDIX E.

This document is compiled based on input from ORP, WRPS management, and knowledgeable fieldwork specialists. These specialists include TOC and ORP management, facility managers, operations leads, cognizant engineers, and design authorities, as well as other knowledgeable Hanford workers. All the known technology needs are identified by the appropriate specialists and summarized via individual TEDS sheets. The TEDS sheets document technology elements, which are components and/or systems requiring development that have been identified as a technology need. Section 3.6 describes how technology elements are aligned with mission initiatives. Individuals including the functional area fieldwork specialists, and ORP use the summaries to prioritize the technology elements.

2.0 ROADMAP TECHNOLOGY DEVELOPMENT SUMMARY

Near-term Technology Needs are identified by WRPS as necessary to begin, continue, or deploy in the next five years for the most efficient use of time and greatest return on investment. Near-term technology needs that have specific identified funding are shown in Table 2-1.

Table 2-1. Near-Term Technology Needs with Funding for FY22/FY23

TEDS ID	Title
DTW-02	Low Temperature Waste Form Process
DTW-03	Immobilized LAW Glass Testing for IDF PA Support
DTW-07	Solidification and Stabilization of Solid Secondary Waste
DTW-08	IDF Long-term Waste Form Durability Study (Lysimeter Data)
MTW-11	DST Primary Tank Bottom Volumetric Inspection
MTW-20	Improve Visual Inspection
MTW-37	Tank Waste Characterization and Identification
MTW-41	Analytical Method Development for Chemicals of Concern
MTW-77	Large Volume Supernatant Sampler and Transportation System
MTW-79	Reduce Entries into Tank Farms while Collecting Vapor Related Data
MTW-87	Real-Time Localized Corrosion Monitoring Probe
MTW-92	Tank Repair
MTW-94	Internal Data Access and Visualization (IDAV)
MTW-95	Predicting Tank Farm Vapor Conditions
MW-02	Ammonia Vapor Mitigation
PTW-23	Methods for Mitigating DFLAW Flowsheet Gaps
PTW-38	Radioactive Waste Test Platform
PTW-53	DFLAW Process Operational Troubleshooting
PTW-55	Chemical Process Modeling Software to Support DFLAW Operations
RTW-01	Retrieval and Closure Solid Waste Sampling Tools
RTW-02	Residual Volume Management System (RVMS)
RTW-08	Dry Sludge Retrieval System
RTW-12	Development of Tank Dome Core Cutter System
RTW-55	Low Volume Addition Retrieval

The Future Technology Needs are those needs that have been identified as profitable areas of focus but are not part of the current five-year vision for technology development and do not have specifically allocated funding. As time goes on and technology needs are fulfilled, retired, or become immediately necessary, needs may move between the Future and Near-term categories. Future Technology Needs are listed in Section 6.0.

3.0 MISSION INTEGRATION

The Roadmap maps technology needs that support accomplishment of ORP's mission. The "End-State Technology Maturation and Execution (TM&E) Chart", Figure 3-1, is a pictorial representation of the technology needs that support that mission. The End State is defined as the completion of technology development activities for equipment, system, and facilities. This Roadmap revision updates the End State TM&E chart and the Near-Term TM&E Chart.

The TM&E charts, Figure 3-1 and Figure 3-2, depict the integration of RPP mission programs and technology maturation activities supporting ORP priorities for thirty years and five years, respectively. In alignment with the current focus of DFLAW and the mission at large, the technology needs are reported in eight major mission programs divided into two areas:

1. Direct Feed Low-Activity Waste (DFLAW) Operations Support
    a. Immobilized Low-Activity Waste Glass
    b. Tank-Side Cesium Removal & Low-Activity Waste a Pretreatment System
    c. Cementitious Waste Forms
    d. Supplemental Low-Activity Waste
2. RPP Mission Support
    a. Alternate Retrieval Technology Identification and Development
    b. Tank Integrity Technology Identification and Development
    c. Sampling & Monitoring Technology Identification and Development
    d. Worker Protection

Major mission programs were identified from existing TEDS sheets, the National Laboratory Technology Capability Matrix (APPENDIX F), other Hanford Site contracts and the RPP Mission Plan, ORP-11242. Development activities were mapped to the major mission programs and the corresponding TEDS are identified. As waste is treated, technology pushes forward and the mission evolves, the programs depicted in the TM&E charts will also evolve.

The technology elements documented in this Roadmap should inform planning decisions. As potential funding becomes available, the elements representing potential technology ideas that can improve operational flexibility, increase processing rates, decrease costs, and/or increase safety should be considered. These charts are updated annually to reflect changing priorities, changing mission needs, and completed development activities.

3.1 DFLAW Operations Support

The near-term mission for the ORP is to treat tank waste using the Low Activity Waste (LAW) Vitrification Facility, which is part of the Waste Treatment and Immobilization Plant (WTP). The DOE has opted to use and prioritize the Direct Feed LAW approach to start treating tank waste. This approach uses the Tank Side Cesium Removal (TSCR) facility to remove Cesium-137 from supernatant and then feed this stream to the LAW Vitrification facility. This approach requires technologies that develop glass formulations, support TSCR, enable cementitious waste forms for secondary waste, and enable Supplemental LAW solidification in cementitious waste forms.

3.1.1 Immobilized Low-Activity Waste Glass

Immobilized LAW (ILAW) glass testing generates the required data for maintenance of the Integrated Disposal Facility (IDF) Performance Assessment (PA) and future revisions to the IDF PA to include Enhanced Waste Glass (EWG) compositions. This work has three primary decision points,

1) Determine how the range of EWG glasses should be represented within the IDF PA to assess against performance objectives
2) Whether sufficient data has been produced for EWG using alternative or traditional test methods to evaluate EWG in the IDF PA
3) Whether statistical correlations between EWG performance and glass composition are necessary and sufficient to assess EWG in the IDF PA

The threats as identified in the Enterprise Risk Opportunity Management System (EROMS) being addressed by Near-Term technology development for ILAW Glass are DFLAW-0363-T, WTP LAW Throughput is Less Than Adequate; DFLAW-0249-T, WIR Evaluation Approval is Delayed; and DFLAW-0149-T, IDF Permits to Operate Including Disposal Authorization Statement (DAS) Delayed. Details on the specific handling actions for each threat can be found in EROMS.

3.1.2 Tank-Side Cesium Removal & Low-Activity Waste Pretreatment System

The TSCR system is a technology that is utilized as a first feed solution supporting the production of ILAW. TSCR is a modular system that removes cesium (Cs) from tank waste supernate prior to feeding it from Tank Farms directly to the WTP LAW Facility. The TSCR system has been deployed as a two-phased demonstration project. The first phase will monitor system performance and demonstrate the ability to safely operate and maintain the TSCR system in support of feed production for WTP hot commissioning and early operations. The second phase will demonstrate the ability to reliably and efficiently treat tank waste for an extended operating period.

The completed TSCR has been deployed and is operating. In support of enhanced future operational efficiency, activities have been identified to support alternate feeds or response to off normal conditions. These activities include development of additional filtration approaches such as alternative media, enhanced cleaning methods, and use of filter pre-coats. Development of these efforts can help ensure operational throughput is maintained when new or unexpected operating conditions are encountered, preserving capability for providing LAW production.

The threats identified in EROMS being addressed by Near-Term technology development for the TSCR & LAW pretreatment system are DFLAW-0363-T, WTP LAW Throughput is Less Than Adequate; DFLAW-0232-T, WTP Radioactive Dangerous Liquid Effluent Composition is Less Than Adequate; DFLAW-0106-T, Staged Treated LAW Feed to WTP Does Not Meet Waste Acceptance Criteria for Cesium-137; DFLAW-0075-T, Secondary Liquid Waste Volumes are Higher Than Expected; DFLAW-1148-T, TSCR Solids Filtration Throughput is Less Than Adequate; and DFLAW-1095-T, TSCR and WFD Systems Unable to meet WTP Feed Demand during Operations. Details on the specific handling action can be found in EROMS.

3.1.3 Cementitious Waste Forms

Advanced grout technology development spans three key areas,

1) Improving contaminant retention and waste form stability for immobilized secondary waste

2) Development and implementation of waste formulations to treat unique process streams such as the high ammonia bearing Effluent Treatment Facility (ETF) effluent brine
3) Formulation development to enhance the retention of key Compounds of Concern (COCs) such as 129-I and 99-Tc to enable the opportunity to break the internal vitrification facility recycle by directly solidifying the bottoms from the Effluent Management Facility (EMF) evaporator.

In addition, the cross-cutting technology maturation needs associated with the long-term stability and durability of cementitious waste forms is addressed in this mission area.

The threats identified in EROMS being addressed by Near-Term technology development for Cementitious Waste Forms are DFLAW-0206-T, Secondary Solid Waste Management Less Than Adequate (Tank Farms and WTP); DFLAW-0232-T, Secondary Liquid Waste Management Less Than Adequate; and DFLAW-0401-O, Alternative Treat/Dispose Path for EMF Evaporator Concentrate. Details on the specific handling actions for each threat can be found in EROMS.

3.1.4 Supplemental Low-Activity Waste

Technology maturation efforts to enable solidifying Supplemental Low Activity Waste (SLAW) into a cementitious waste form include,

1) Quantifying and resolving issues associated with the possible presence of RCRA LDR organics in SLAW
2) Developing tailored waste formulations to enhance the ability of solid matrices to Capture-and-Hold the problematic constituents, 129-I, 99-Tc, and Nitrate
3) Evaluating modifications to the waste packages and IDF backfill to enhance retention of hazardous and radioactive constituents within the IDF footprint

Both onsite as well as offsite disposal options are considered in this work. Offsite disposal requirements are included to address opportunities for enhancing the waste treatment mission.

The threat identified in EROMS being addressed by Near-Term technology development by Near-Term technology development for SLAW is DFLAW-0363-T, WTP LAW Throughput is Less Than Adequate. Details on the specific handling action can be found in EROMS.

3.2 RPP Mission Support

Other mission needs fall under RPP Mission Support which is working toward the mission End-State. This includes identifying and developing technologies to address alternate retrieval methods, tank integrity verification and improvement, waste sampling and monitoring methods, and overall worker protection.

3.2.1 Alternate Retrieval Technology Identification and Development

Alternate retrieval addresses the technologies needed to identify, develop, and allow successful deployment of new or enhanced Alternative Retrieval Technologies (ART) for solids removal from waste tanks at the Hanford Site tank farms. The goal of this program is to develop the technology necessary to support retrieval of the remaining tank waste solids in a safe and efficient manner. Tank retrieval activities are governed by ORP-11242, *River Protection Project System Plan*, herein after referred to as the System Plan and by RPP-PLAN-40145, *Single-Shell Tank Waste Retrieval Plan*.

The threats identified in EROMS being addressed by Near-Term technology development for ART are

AAXRC-0012-T, Delays in A-104 and A-105 Retrieval Due to Technology Development; AAXRC-0016-T, Excessive Equipment Failures (other than pumps); AAXRC-0051-T, Damage to Tank/Equipment During Equipment Installation or Removal; and AAXRC-0043-T, Equipment in Risers is More Difficult to Remove than Anticipated (DOE). Details on the specific handling actions for each threat can be found in EROMS.

3.2.2 Tank Integrity Technology Identification and Development

The primary objectives of the Tank Integrity programs are to monitor the condition of the valuable Double Shell Tank (DST) assets over time, evaluate any unanticipated changes in condition and rectify them where feasible. The data obtained by these programs serves to inform future operational and inspection decisions. To date, discoveries of tank bottom corrosion in the primary tank of DST AY-102, material loss from the foundation side of the secondary liner of several DSTs, and liquid-to-air interface corrosion in tank AY-101 have served to spur additional action to prolong the life of the DSTs and mitigate damage mechanisms as they are discovered. Discovery of these challenges early on is a critical component of the integrity program mission.

The Non-Destructive Examination (NDE) technologies consist of surface and volumetric techniques. Surface NDE technologies to date have focused on improved visual inspection of the DSTs. Consideration is being given to other methods of examination. Volumetric NDE techniques target inspection of the material to characterize any degradation present, such as thinning, pitting, cracking and other surface defects. To date ultrasonic testing has been the primary method used; the program is investigating other methods such as guided wave and electromagnetic acoustic transducers.

Tank Integrity also includes Tank repair activities. The DSTs are expected to provide sufficient capacity for retrieving waste from SSTs for treatment and stabilization; remaining in operation for several decades beyond their originally planned operating life. The Hanford mission relies on the availability of DSTs to ensure that there is sufficient storage space in the tank farms during the life of the mission. Identifying and developing a toolbox of technologies that can affect a range of repair needs will improve potential storage space options and provide confidence in overall tank integrity.

The threats identified in EROMS being addressed by Near-Term technology development for Tank Integrity are TFIRR-0045-T, DST Tank Failure in East Area; TFIRR-0046-T, DST Tank Failure in West Area; TFIRR-0047-T, SST Failure in East Area; TFIRR-0048-T, SST Failure in West Area; AAXRC-0012-T, Delays in A-104 and A-105 Retrieval Due to Technology Development; and AAXRC-0024-T, Waste Temperatures Exceed HIH Limits. Details on the specific handling actions for each threat can be found in EROMS.

3.2.3 Sampling & Monitoring Technology Identification and Development

The primary driver for all sampling technologies is successful support of the RPP tank waste cleanup mission needs. To help prevent the risk of mission delays, all future project and mission elements need to be assessed as soon as possible for any potential waste sampling technology gaps. Identifying gaps in advance will allow ample time to develop the needed technologies to meet mission goals.

The threats identified in EROMS being addressed by Near-Term technology development for Sampling and Monitoring are AAXRC-0011-T, Waste Not as Expected (different than modeled) – Takes Longer or Cannot be Retrieved; AAXRC-0024-T, Waste Temperatures Exceed HIH Limits; and DFLAW-0232-T, WTP Radioactive Dangerous Liquid Effluent Composition Less Than Adequate. Details on the specific handling actions for each threat can be found in EROMS.

3.2.4 Worker Protection

The purpose of worker protection is to identify, develop, and deploy new or enhanced worker protection program technologies for protection of Hanford Site tank farm workers and associated Hanford workers (other DOE Site subcontractors) from potential hazards. The technology effort focus is to determine, with the Hanford work force (management, technical staff and field workers), what the potential hazards are, the extent of the hazard and what technologies can be developed and deployed to mitigate the hazards to acceptable and/or required safe conditions.

The threat identified in EROMS being addressed by Near-Term technology development for Worker Protection is WRPSC-0003-T, Tank Vapors Controls Impact Project Execution.

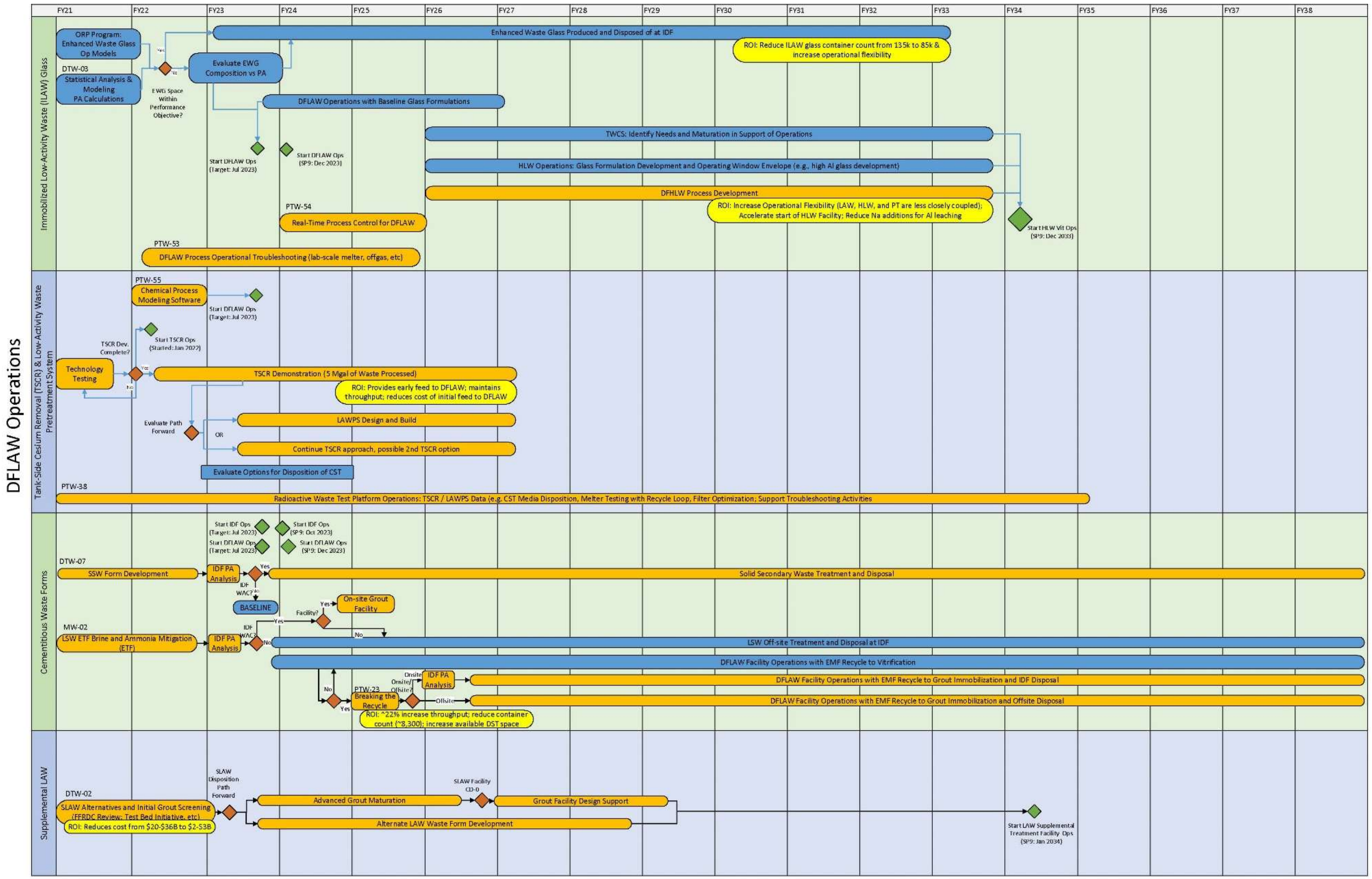
3.3 End-State Technology Maturation and Execution Chart

The End-State TM&E chart, Figure 3-1, includes an assessment of mission program impacts (i.e., return on investment) for key project technology development initiatives. Technology developments that present potential significant benefit to accomplishing the RPP mission are included. These are identified as key opportunities for each mission program. RPP mission programs also include those technology development activities that envelope all tank farm activities (e.g., worker protection).

Both TM&E charts employ a color/shape coding of activities. This enables a quick visual understanding of end-state support. The coding is as follows:

- (Blue oval) ORP-11241, System Plan, Baseline Case
- (Green oval) Technology development basis that could have substantial positive impact on the Infrastructure and Operations cost and schedule and/or program threat
- (Yellow oval) Technology development benefits (estimated cost savings, schedule savings, and threat reductions) to the RPP mission
- (Orange oval) Technology development activity basis for enhancing the efficient execution of the WTP mission
- (Purple oval) Technology Innovations
- (Gray oval) Technology development activity that has been retired
- (Green diamond) Programmatic Milestone – Pending decisions that require technology support
- (Orange diamond) Key Decision – Decisions concerning technology deployment in support of mission milestones

Figure 3-1. End-State Technology Maturation and Execution



1) Direct-Feed High-Level Waste (PTW-40)
a) Reduce Coupling between ILAW, HLW, and PT Facilities
b) Accelerate start of HLW Facility
c) Reduce Na additions for Al leaching pretreatment

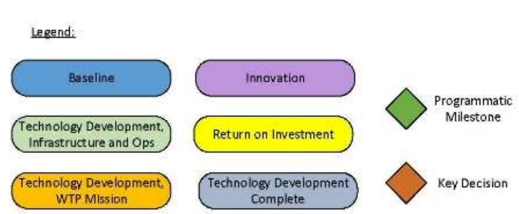
1) Operation of Radioactive Waste Test Platform (PTW-38)
a) IX performance on out-year waste – provide early indicator of future feed streams
b) Evaluate waste stability – identify potential impacts of processing S Tank Farm feed through IX columns
c) CST development – eliminate current sole-source to reduce cost and risk
d) Modify to evaluate HLW operations – provide early indication of unit operation performance
e) Grout optimization – provide alternate immobilization path by evaluating product performance

2) Prevention of Hydrogen Gas Generation (PTW-48)
a) Necessary if changing the operational parameters

1) Alternate Disposition Path of EMF Recycle (PTW-23)
a) 22% increase in throughput
b) ~8,300 reduction in container count
c) Increase available DST space

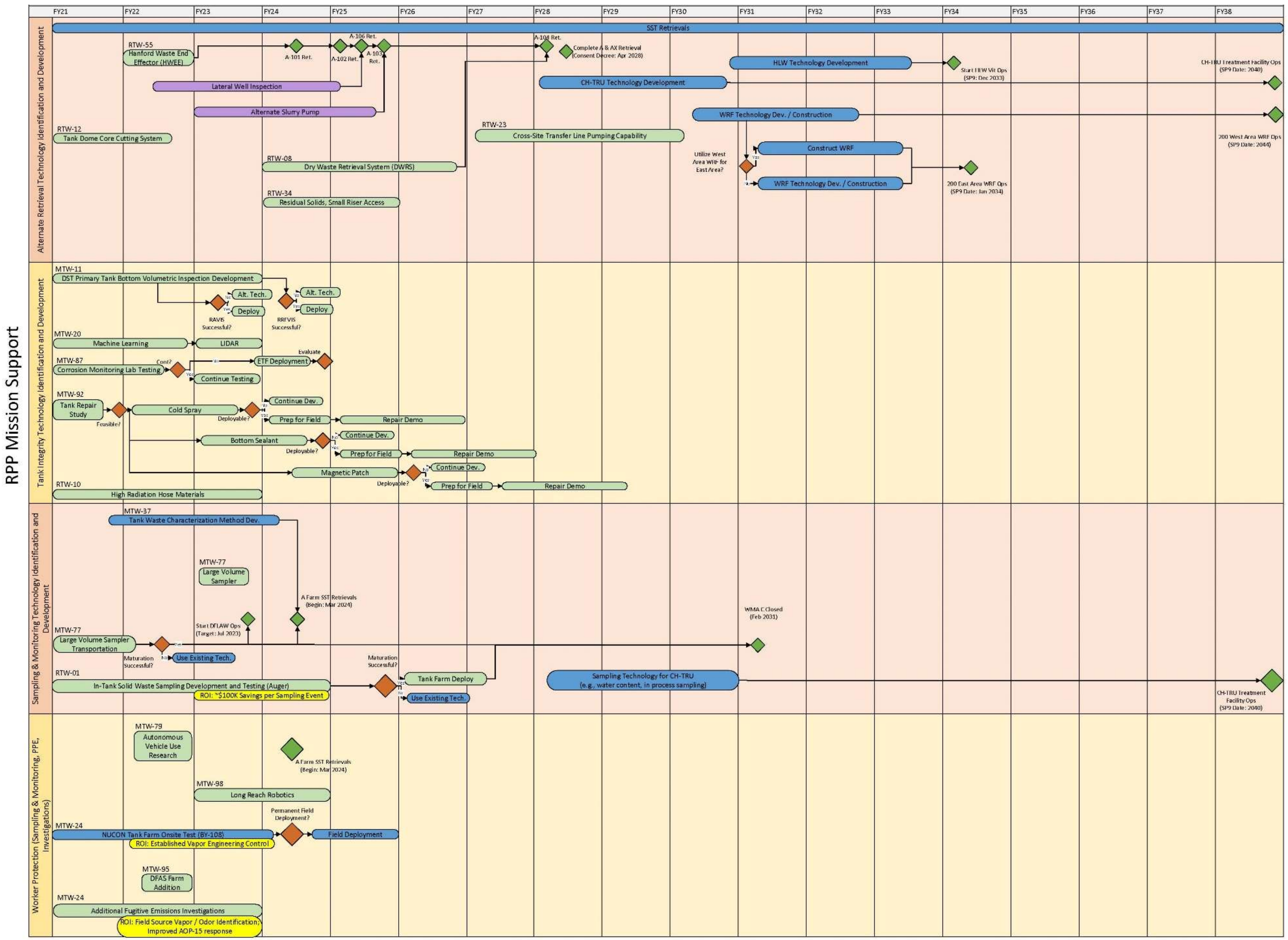
2) IDF Long-Term Waste Form Lysimeter Data Study (DTW-08)
a) Improves stakeholder confidence in disposal facility and waste form performance
b) Reduce conservatism in release estimates
c) Better utilization of IDF
d) Lower IDF closure cost

1) Alternative LAW Disposition Paths (DTW-02)
a) Reduces close coupling of treatment facilities
b) Reduces cost of LAW immobilization
c) Up to 10 years reduced mission life cycle
d) Projected cost savings/avoidance



Acronyms:

CEM	Continuous Emissions Monitor	FY	Fiscal Year	MWGS	Mechanical Waste Gathering System	SPFT	Single-Pass Flow Through
COPC	Chemical of Potential Concern	Hg	Mercury	Na	Sodium	SRCA	Stirred Reactor Coupon Analysis
Cs	Cesium	HLW	High Level Waste	OEL	Occupational exposure limit	SST	Single-Shell Tank
CST	Crystalline silicotitanate	HWEE	Hanford Waste End Effector	ORP	DOE Office of River Protection	SSW	Solid Secondary Waste
CWF	Cementitious Waste Form	IDF	Integrated Disposal Facility	PA	Performance Assessment	TBD	To Be Determined
DFHLW	Direct-Feed High-Level Waste	ILAW	Immobilized Low-Activity Waste	PCT	Product Consistency test	Tc	Technetium
DFLAW	Direct-Feed Low-Activity Waste	IX	Ion Exchange	PPE	Personal Protective Equipment	TEDS	Technology Element Description Sheet
DST	Double Shell Tank	LAW	Low-Activity Waste	PT	Pretreatment	TRL	Technology Readiness Level
DTW	Dispose Tank Waste	LAWPS	Low-Activity Waste Pretreatment System	PTW	Process Tank Waste	TRU	Transuranic
EMF	Effluent Management Facility	LIBS	Laser-Induced Fluorescence	RCCS	Rotary Core Cutting System	TSCR	Tank-Side Cesium Removal
ERSS	Extended-Reach Sluicing System	LSW	Liquid Secondary Waste	ROI	Return On Investment	TWCS	Tank Waste Characterization and Staging
ETF	Effluent Treatment Facility	MIP	Multi-isotope Process	RTW	Retrieve Tank Waste	VOC	Volatile Organic Chemical
EWG	Enhanced Waste Glass	MTW	Manage Tank Waste	RVMS	Residual Volume Measuring System	WAC	Waste Acceptance Criteria
		MW	Manage Waste	SLAW	Supplemental Low-Activity Waste	WRF	Waste Receipt Facility



Key Opportunities

1) ERSS Modifications (RTW-34)
  a) Improve Efficiency of waste removal by enhancing range of motion of ERSS (utilize less arms during retrieval and avoid obstructions)
  b) Increase pumping capability over greater range of solids rheological properties

2) High-Radiation Hose Material Testing (RTW-10)
  a) Increased lifecycle of hose-in-hose exposed to high-radiation environment and reduce cost

3) Development of an RCCS to Improve Access Inside the Tanks (RTW-12)
  a) Reduced worker exposure during core drilling activities
  b) Increases riser size, increasing range of retrieval technologies, including commercial off-the-shelf technologies

4) HWEE Development (RTW-55)
  a) 2-5X improvement in retrieval rate
  b) 10x improvement in dilution ratio

1) Automated DST Annulus Camera System (MTW-09)
  a) Reduce cost and exposure of annulus inspections
  b) Increase frequency and timeliness of event response

2) Radiation Tolerant Multi-Use Manipulator (MTW-81)
  a) Enhanced sensor deployment method, reducing cost and exposure

1) Tank Waste Characterization and Identification (MTW-37)
  a) Improved equipment reduces uncertainty with analytical results
  b) Improves exposure to technicians ALARA

2) Use of Sonar and Ultrasound to Quantify Solids in DSTs (RTW-44)
  a) Reduced uncertainty in solids measurements
  b) More accurate measurements reduce conservatism in tank waste evaluations
  c) Reduced schedule for volume determination
  d) Reduced dose to workers and simplifies measurement technique

3) Three-Dimensional Flash LIDAR to Map Waste Tanks (RTW-53)
  a) Reduced uncertainty in residual measurements
  b) Reduced schedule for tank waste mapping
  c) Reduced dose to workers and simplified measurement technique

4) Online Monitoring (e.g., Raman Spectroscopy) (MTW-76)
  a) Reduced sample operations cost
  b) Reduced analysis duration

1) Self-Diagnosing Continuous Air Monitoring (MTW-72)
  a) Minimize need for maintenance and personnel to service equipment during daily rounds

2) Autonomous Robotic Platform (MTW-79)
  a) Reduced worker exposure through reduced tank farm entries
  b) Collect tank and vapor data in remote farms prior to initiating waste-disturbing activities
  c) Enhance tank farm walk-down capabilities

3) Mobile Proton Transfer Reaction – Mass Spectrometer (MTW-68)
  a) allows for near real time detection (e.g., ultraviolet – differential optical spectrometer) of COPCs at OELs
  b) Improved temporal resolution, low part per trillion sensitivity and extremely high mass resolution

4) CEM (MTW-24)
  a) Stack, area, and headspace monitor
  b) Autonomous, programmable whole-air sampling capability

3.4 Near-Term Technology Development

The Roadmap provides a focused look at the next five years in addition to the longer-term mission integration. This focused look at the near-term mission is intended to provide clarifying information to aid in the planning of projects. For continuity, the near-term focus is depicted in a Near-Term TM&E chart, Figure 3-2, that is divided into the same areas and major mission programs as the End-State TM&E chart. The Near-Term TM&E chart lists TEDS's numbers that are on-going activities starting with the FY22. The chart also contains recommendations/expectations for subsequent fiscal years. These TEDS's numbers are as follows,

DFLAW Operations Support

Immobilized Low Activity Waste Glass

- DTW-03, Immobilized ILAW Glass Testing for IDF PA Support
- PTW-53, DFLAW Process Operational Troubleshooting
- PTW-54, Real-Time Process Control for DFLAW

Tank-Side Cesium Removal & Low-Activity Waste Pretreatment System

- PTW-38, Radioactive Waste Test Platform
- PTW-55, Chemical Process Modeling Software to Support DFLAW Operations

Cementitious Waste Forms

- DTW-07, Solidification and Stabilization of Solid Secondary Waste
- DTW-08, IDF Long-term Waste Form Durability Study (Lysimeter Data)
- MW-02, Ammonia Vapor Mitigation
- PTW-23, Methods for Mitigating DFLAW Flowsheet Gaps

Supplemental Low-Activity Waste

- DTW-02, Low Temperature Waste Form Process

RPP Mission Support

Alternate Retrieval Technology Identification and Development

- RTW-08, Dry Retrieval Systems
- RTW-12, Development of New Riser Installation System
- RTW-34, Remove Residual Solids in Non-Leaking Tanks
- RTW-55, Low Volume Addition Retrieval

Tank Integrity Technology Identification and Development

- MTW-11, DST Primary Tank Bottom Volumetric Inspection
- MTW-20, Improve Visual Inspection
- MTW-87, Real-Time Localized Corrosion Monitoring
- MTW-92, Tank Repair
- RTW-10, Evaluation of Hose-in-Hose Transfer Line (HIHTL) Material Properties

Sampling & Monitoring Technology Identification and Development

- RTW-01, Retrieval and Closure Solid Waste Sampling Tools
- MTW-77, Large Volume Supernatant Sampler and Transportation System

Worker Protection

- MTW-24, Vapor Monitoring, Characterizing & Remediation
- MTW-79, Reduce Entries into Tank Farms while Collecting Vapor Related Data
- MTW-95, Predicting Tank Farm Vapor Conditions

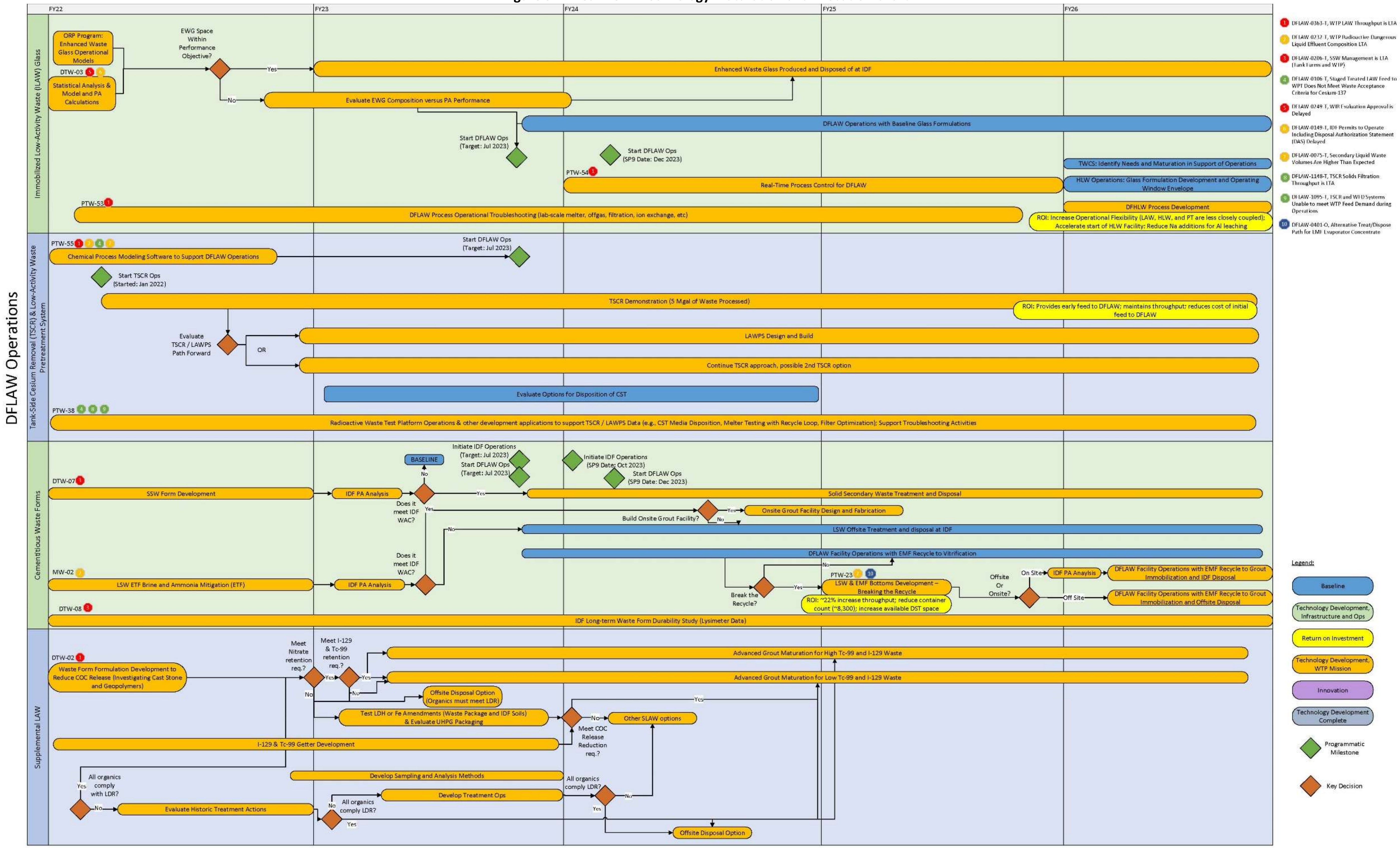
More information on each of these needs can be found in the corresponding Catalog Sheets Section 5.0.

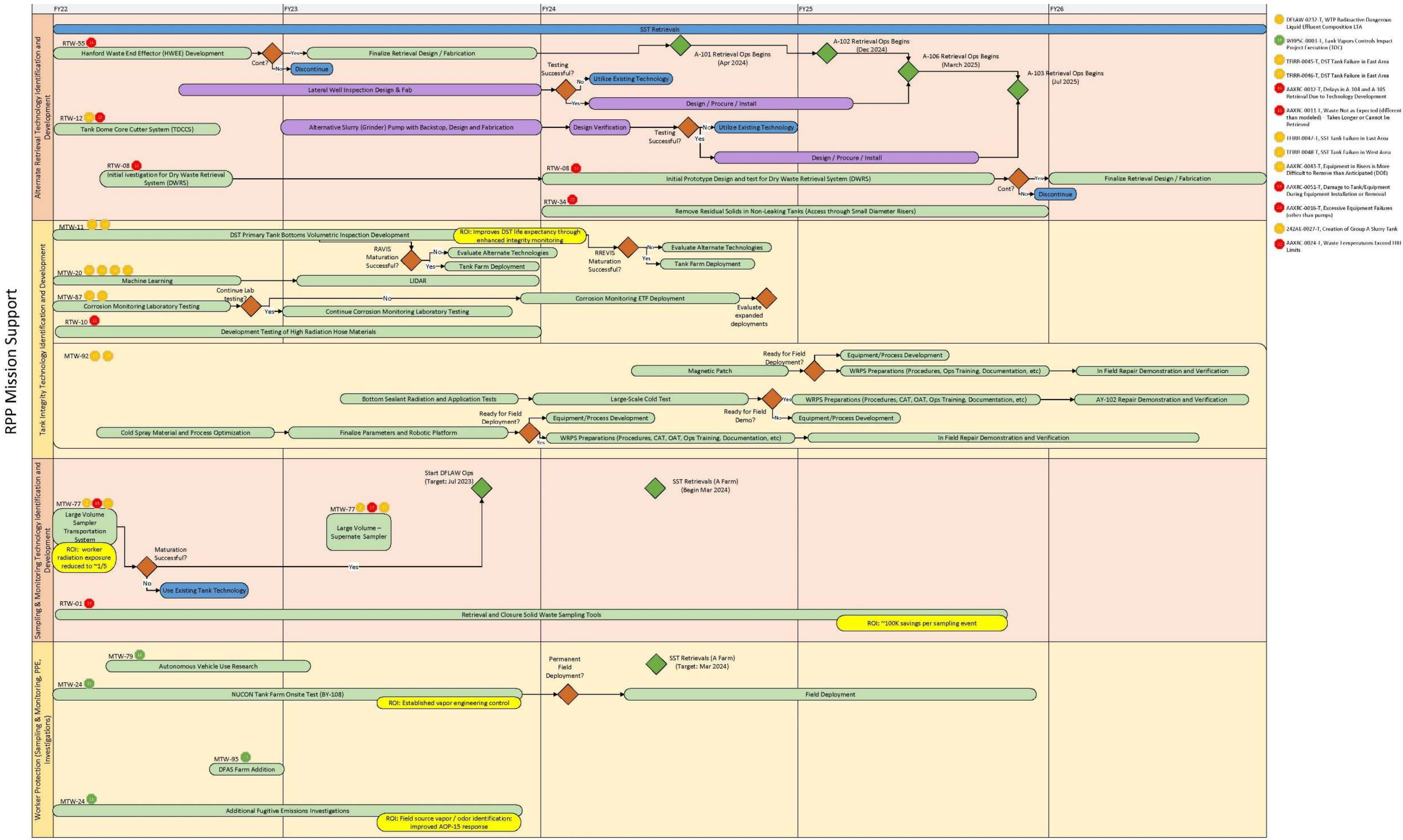
3.5 Near-Term Technology Maturation and Execution Chart

The Near-Term TM&E chart, Figure 3-2, gives a clearer, more detailed breakdown of tasks and task durations of projects. This chart is used to highlight and identify the projects that are both in progress and those that are needed in the near future. This chart includes the on-going activities from the fiscal year this revision of the Roadmap was published with recommendations/expectations for the following four fiscal years. Additionally, the Missions Risks as identified in the Enterprise Risk Opportunity Management System (EROMS) are called out by identification number and title to provide a clearer understanding of the need for the technology development. Each TEDS identification number on the chart is accompanied by a risk identifier that is the color of the risk level as identified in EROMS and corresponds to the EROMS Identification number indicated on the right hand side of the chart.

The near-term TM&E chart is divided into the same eight major mission programs in two areas as the End State TM&E chart and includes a finer project timeline for the near-term projects. Technology development is ongoing in each of the major mission programs.

Figure 3-2. Near-Term Technology Maturation and Execution Chart

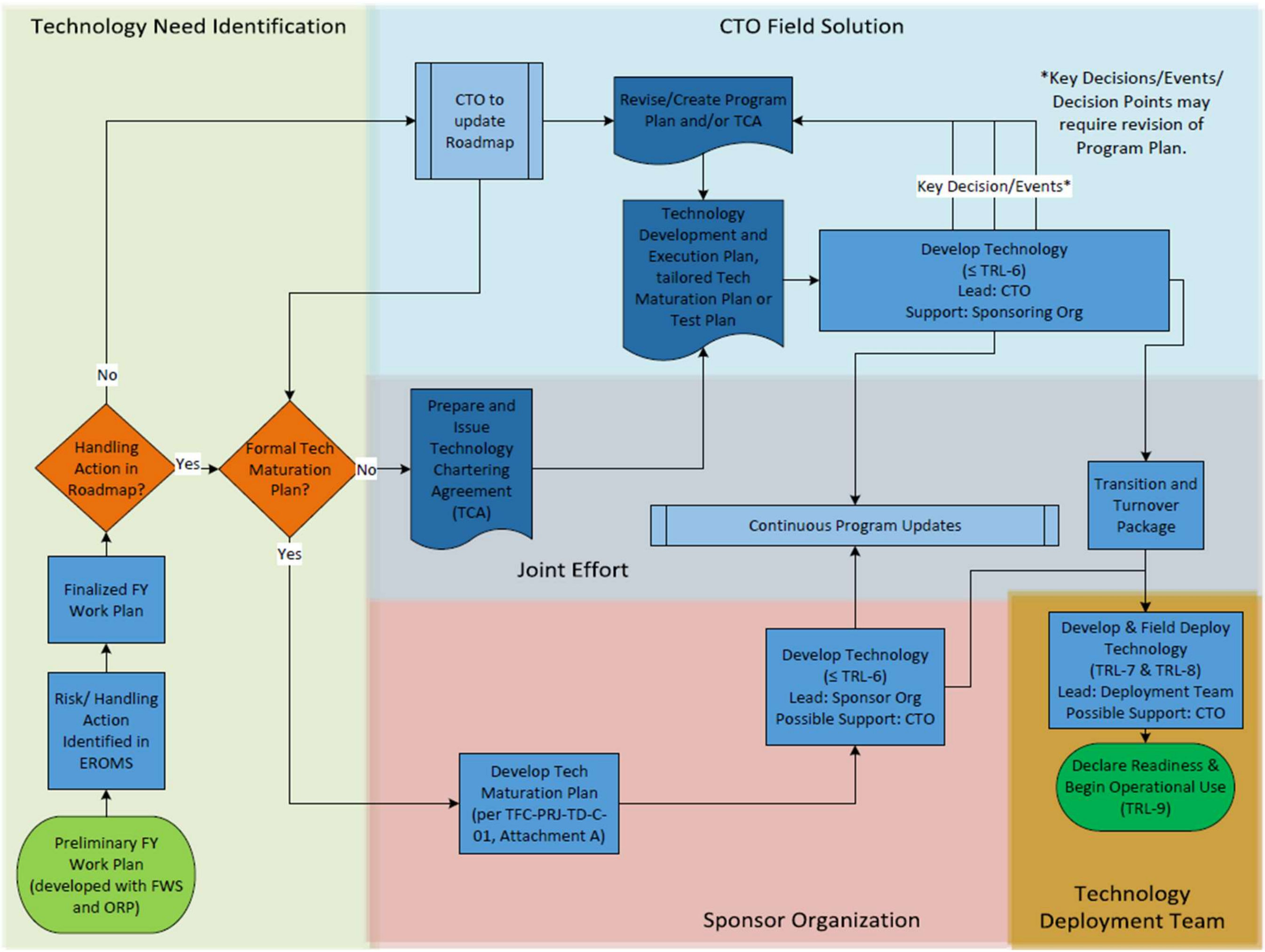



RPP Mission Support
FY22
FY23
FY24
FY25
FY26
Alternate Retrieval Technology Identification and Development
SST Retrievals
RTW-55
Hanford Waste End Effector (HWEE) Development
Cont?
Yes
No
Finalize Retrieval Design / Fabrication
Discontinue
A-101 Retrieval Ops Begins (Apr 2024)
A-102 Retrieval Ops Begins (Dec 2024)
A-106 Retrieval Ops Begins (March 2025)
A-103 Retrieval Ops Begins (Jul 2025)
Testing Successful?
Utilize Existing Technology
Lateral Well Inspection Design & Fab
Design / Procure / Install
RTW-12
Tank Dome Core Cutter System (TDCCS)
Alternative Slurry (Grinder) Pump with Backstop, Design and Fabrication
Design Verification
Utilize Existing Technology
Design / Procure / Install
RTW-08
Initial ivestigation for Dry Waste Retrieval System (DWRS)
Initial Prototype Design and test for Dry Waste Retrieval System (DWRS)
Finalize Retrieval Design / Fabrication
Discontinue
RTW-34
Remove Residual Solids in Non-Leaking Tanks (Access through Small Diameter Risers)
Tank Integrity Technology Identification and Development
MTW-11
DST Primary Tank Bottoms Volumetric Inspection Development
ROI: Improves DST life expectancy through enhanced integrity monitoring
RAVIS Maturation Successful?
Evaluate Alternate Technologies
Tank Farm Deployment
RREVIS Maturation Successful?
Evaluate Alternate Technologies
Tank Farm Deployment
MTW-20
Machine Learning
LIDAR
MTW-87
Corrosion Monitoring Laboratory Testing
Continue Lab testing?
Continue Corrosion Monitoring Laboratory Testing
Corrosion Monitoring ETF Deployment
Evaluate expanded deployments
RTW-10
Development Testing of High Radiation Hose Materials
MTW-92
Ready for Field Deployment?
Equipment/Process Development
Magnetic Patch
WRPS Preparations (Procedures, Ops Training, Documentation, etc)
In Field Repair Demonstration and Verification
Bottom Sealant Radiation and Application Tests
Large-Scale Cold Test
WRPS Preparations (Procedures, CAT, OAT, Ops Training, Documentation, etc)
AY-102 Repair Demonstration and Verification
Ready for Field Demo?
Equipment/Process Development
Cold Spray Material and Process Optimization
Finalize Parameters and Robotic Platform
Ready for Field Deployment?
Equipment/Process Development
WRPS Preparations (Procedures, CAT, OAT, Ops Training, Documentation, etc)
In Field Repair Demonstration and Verification
Sampling & Monitoring Technology Identification and Development
Start DFLAW Ops (Target: Jul 2023)
SST Retrievals (A Farm) (Begin Mar 2024)
MTW-77
Large Volume Sampler Transportation System
ROI: worker radiation exposure reduced to ~1/5
Maturation Successful?
Use Existing Tank Technology
Large Volume – Supernate Sampler
RTW-01
Retrieval and Closure Solid Waste Sampling Tools
ROI: ~100K savings per sampling event
Worker Protection (Sampling & Monitoring, PPE, Investigations)
MTW-79
Autonomous Vehicle Use Research
Permanent Field Deployment?
SST Retrievals (A Farm) (Target: Mar 2024)
MTW-24
NUCON Tank Farm Onsite Test (BY-108)
ROI: Established vapor engineering control
Field Deployment
MTW-95
DFAS Farm Addition
MTW-24
Additional Fugitive Emissions Investigations
ROI: Field source vapor / odor identification: improved AOP-15 response
DFLAW-0232-T, WTP Radioactive Dangerous Liquid Effluent Composition LTA
WRPSC-0003-T, Tank Vapors Controls Impact Project Execution (TOC)
TFIRR-0045-T, DST Tank Failure in East Area
TFIRR-0046-T, DST Tank Failure in East Area
AAXRC-0012-T, Delays in A-104 and A-105 Retrieval Due to Technology Development
AAXRC-0011-T, Waste Not as Expected (different than modeled) – Takes Longer or Cannot be Retrieved
TFIRR-0047-T, SST Tank Failure in East Area
TFIRR-0048-T, SST Tank Failure in West Area
AAXRC-0043-T, Equipment in Risers is More Difficult to Remove than Anticipated (DOE)
AAXRC-0051-T, Damage to Tank/Equipment During Equipment Installation or Removal
AAXRC-0016-T, Excessive Equipment Failures (other than pumps)
242AE-0027-T, Creation of Group A Slurry Tank
AAXRC-0024-T, Waste Temperatures Exceed HIH Limits

3.6 Transition to Operations

Transitioning equipment, systems, and facilities from start-up and commissioning to field operations may require the deployment of different technologies. Additional technology development and/or studies may be required to support commissioning and field operations. For this reason, CTO will work closely with the sponsoring organization to ensure continuity between technology development and deployment. See the figure below.

Figure 3-3. Technology Development Flow Chart

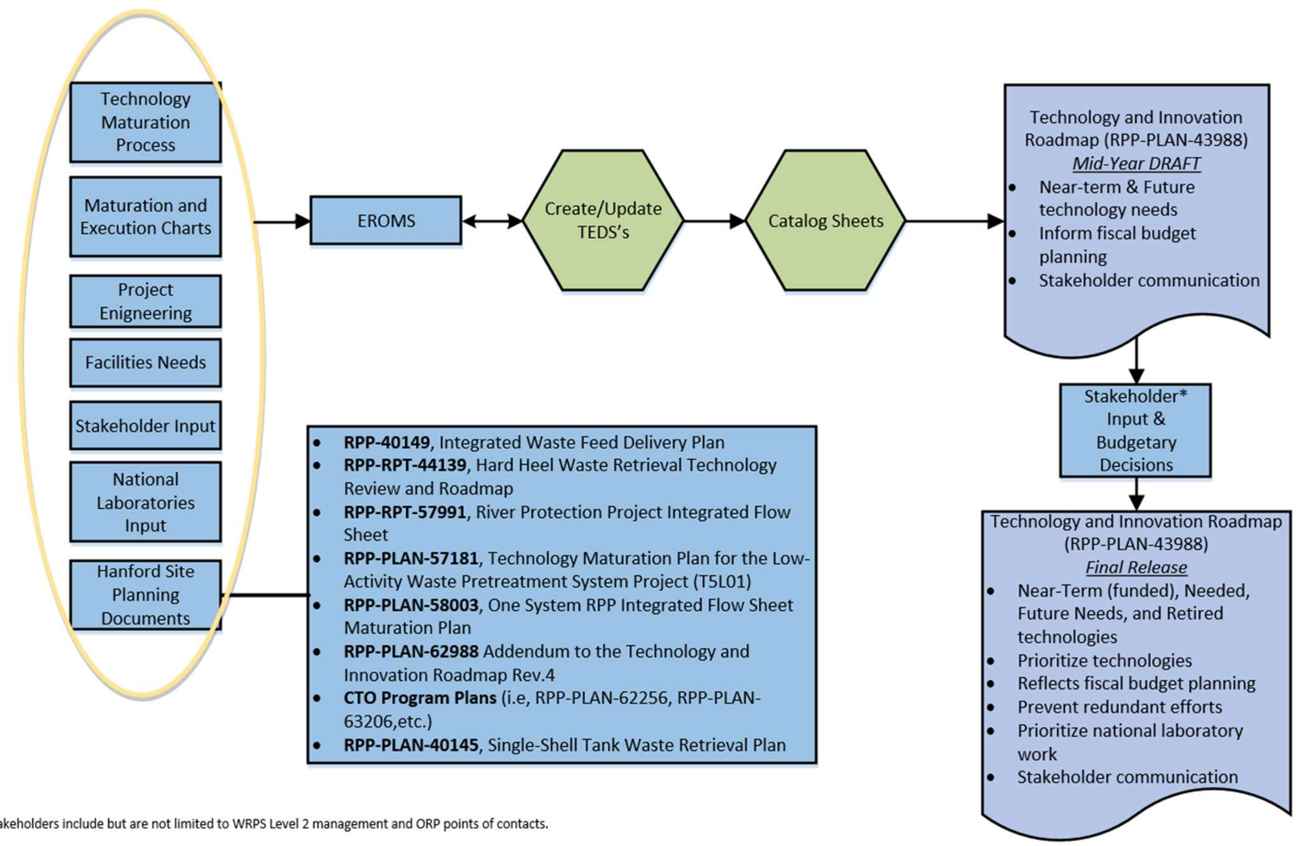


4.0 PROCESS SUMMARY

The technology maturation process as defined in TFC-PLN-90, *Technology Maturation Management Plan*, defines technology elements that are incorporated into TEDS sheets as necessary. After technology development needs are received from throughout the company, the DOE complex (contractors to DOE), and outside industries, Hanford Site planning documents are reviewed to identify any technology needs that were missed. Figure 4-1 highlights some of the planning documents that are reviewed. A TEDS sheet is generated for any additional technology needs.

This Roadmap is updated annually to incorporate the changing RPP technology needs. Figure 4-1 illustrates this process, which initiates with the solicitations of technology needs from a variety of sources.

Figure 4-1. Technology Roadmap Development Process



*Stakeholders include but are not limited to WRPS Level 2 management and ORP points of contacts.

This process is used to ensure that the planning and strategic initiatives agree. These sources include: (1) previous year's Roadmap (Legacy Technology Outputs); (2) technologies derived through technology maturation; (3) TM&E chart (Figure 3-1); (4) stakeholder input; (5) facility needs; (6) EROMS; (7) ORP Grand Challenges (GC); and (8) programmatic planning documents. Most of these inputs are Hanford-centered, but the ORP GC obtained solicitations from industry, academia, and the DOE-wide complex. The GC program was discontinued, and no new GCs have been produced since 2018.

Ultimately, all technology elements will be mapped to programmatic and project threats and opportunities via EROMS. This is an ongoing process facilitated through interaction with risk engineers. EROMS is the web-based application that WRPS uses to identify and manage Threats (or Risks) and Opportunities (T&Os). The principal reasons for employing EROMS are to identify and manage those Threats and Opportunities (T&Os) that may have significant impact on achieving goals and objectives of the entire WRPS enterprise, and to provide a basis for prioritizing and allocating limited resources required to implement recommended handling strategies.

T&Os are addressed at multiple levels, from Line organizations (which includes all functional organizations), through Projects and Programs, and up to the Business, or top level. All of these T&Os are subject to potential interfaces with entities external to WRPS, such as other Hanford site contractors, the DOE, or other stakeholders (e.g., Washington State regulators, Defense Nuclear Facility Safety Board, Congress). It is important to note that T&Os are normally managed at the lowest possible level, and only those that have higher level impacts or that require resources beyond those available to the current organizational level would get elevated to the next level in the hierarchy. In addition, only those T&Os with significant potential impact to the overall organization would be elevated to the enterprise level where they would be managed as directed by the Senior Management Team (SMT).

4.1 Compiling Technology Element Description Summaries (TEDS)

All of the known technology needs are identified by the appropriate Fieldwork Specialists via individual TEDS sheets. In Revisions 0 through 3 of the Roadmap, TEDS sheets were referred to as pro forma work sheets. Beginning in Revision 4 existing ProFormas were updated to the TEDS format (see a sample TEDS form in APPENDIX A) and additional TEDS sheets were developed to address new technology needs. The TEDS sheets were used from Revision 4 through Revision 7. At Revision 7, the data from the TEDS was migrated into a database application for ease of management.

The TEDS is a standardized work sheet that enables direct comparison of provided input. The TEDS sheets primarily include the following information:

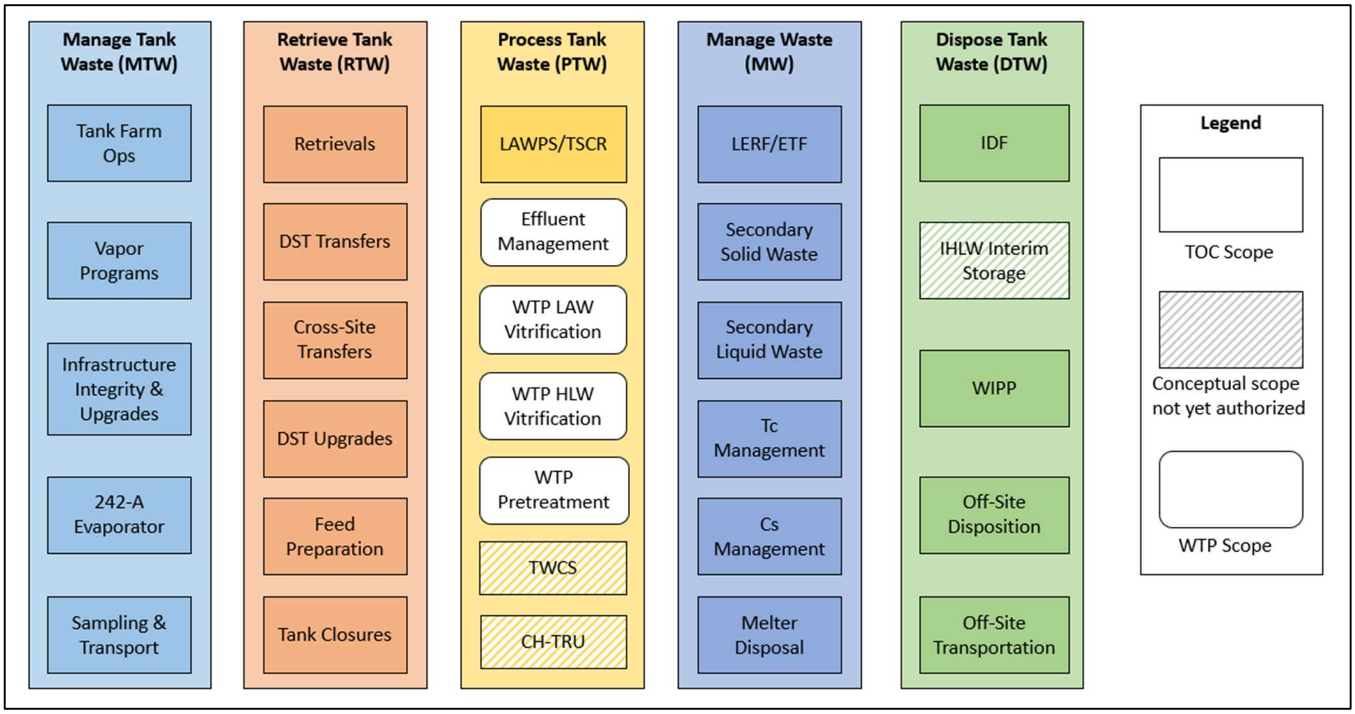
- Funding Status
- Technology Summary
- Priority Ranking
- Functional Area
- Cost and Schedule
- Points of Contact
- Technology Need
- Technology Solution
- Technology Maturation Level
- National Laboratory Involvement
- Grand Challenge Relationship
- Technology Impact and Threat Identification

To kick-off the request for TEDS sheets and ensure that the technology needs and gaps are comprehensively captured, the WRPS Chief Technology Office assembled a team with extensive experience in Hanford Site tank farms that spanned all mission functional areas.[1] This team included ORP and WRPS personnel, including managers and technical leads and individuals with field experience. Although WTP technology development is identified in the functional framework, this

[1] The RPP mission functional areas are in alignment with the DE-AC27-08RV14800 Tank Operations Contract work breakdown structure and are discussed further in RPP-51303, *River Protection Project Functions and Requirements*, and RPP-RPT-56516, *One System River Protection Project Mission Analysis Report*.

roadmap currently does not include WTP technology development activities. The five mission functional areas are depicted in Figure 4-2. Having experienced Hanford Site members for all five functional areas served as a way to ensure all of the RPP mission requirements have coverage in the Roadmap.

Figure 4-2. Functional Area Summary



For Revision 7, CTO reached out to the relevant WRPS, ORP, and other Fieldwork Specialists and requested any additional technology needs that were not addressed by the previous year's TEDS, and new TEDS sheets were created as necessary. The primary input into the technology needs was the TM&E chart (see Figure 3-1 in Section 2.0).

Technology development is primarily driven by the need to mitigate threat and realize opportunity; therefore, the risk registries are significant input into the technology needs. The threats and opportunities are identified, managed, and assessed via the EROMS which is also known as the Risk Registry. A key feature of the Risk Registry is handling actions. Handling actions propose what is or could be done about threats or opportunities to minimize or maximize the impacts to the work scope. A section of the TEDS form requests the threat and opportunity input. This input includes the handling actions that could be implemented by the proposed technology development. Additionally, opportunities identified in the Risk Registry are assessed for technology development application.

Previously, the ORP GC Workshop brought together members of DOE, National Laboratories, academia, contractors, and outside industries. ORP has not solicited GCs for FY 2022, but previous years' ideas that are related to technology development have previously been incorporated into TEDS sheets. The catalog sheets indicate GC participation from previous years only.

4.2 Catalog Sheets

The catalog sheets for projects that are planned for FY22 make up Section 5.0 of this Roadmap.

Information provided by the TEDS sheets is used to prepare the Roadmap catalog sheets highlighting each technology need. The catalog sheets are concise summaries of technology developments. They are shared with other DOE Sites, National Laboratories, and vendors as needed. Current activities are primarily those that are needed in the near (<5 years) or intermediate (5-10 years) time frame. Technology developments that are planned for FY22 are described on two pages identifying needs, solutions, threats, opportunities, activity duration, funding, interfacing contractor, and ORP contact information. The relationship between a TEDS and a catalog sheet is defined in APPENDIX D.

Technology developments that are identified but not planned for the next fiscal year are described on single page catalog sheets. These catalog sheets contain rough-order-of-magnitude cost and duration information.

The basis of estimate provided for out-years is the best estimate for the work scope. The best estimate values may not reflect baseline funding, in which case the duration of performance could change.

Included in the two-page Catalog sheets is a Measurable Organizational Value (MOV). An MOV is a measure of the overall goal and defines the measure of success. A MOV must be measurable, verifiable, and provide organization value. In assembling the MOV for each TEDS the project leads follow a set of steps. The project lead identifies the desired area of impact and desired value of eliminating the threat or realizing the opportunity. Using this information, an appropriate metric is developed, this includes assigning a time frame for achieving the MOV. The financial models that can be incorporated to showcase the tangible metric values of impact(s) include payback, breakeven, return on investment, net present value, or scoring. This in turn is then used to develop a clear and concise statement or table for the TEDS. The final step in this process is verifying MOV and documenting agreement from project sponsors, end users, and other key stakeholders. Since no single solution generally exists for most threat or opportunities, it is acceptable to identify several TEDS; these alternatives, or options, identified in the threat or opportunity assessment can be used as a strategy for achieving a single MOV.

4.3 Technology Roadmap Document

After catalog sheets are finalized, the Roadmap is compiled and released for use within the DOE complex. The Roadmap is a living document that is updated annually to accommodate changing needs of the RPP mission. As such, it will be a key resource for preparing program plans, transition plans, and out-year Roadmaps.

The extensive input to the Roadmap results in a multi-faceted output. The Roadmap is to be used as a planning tool for making informed budgetary decisions and to track the progress of ongoing technology development efforts, including completed tasks or abandoned efforts which are identified as “retired”. Ideally, the Roadmap will identify redundant efforts and gaps in technology development to optimize the approach taken to bring key technologies onto the Hanford Site. APPENDIX E describes CTO technology development achievements.

5.0 NEAR-TERM TECHNOLOGY DESCRIPTIONS

This section presents catalog sheets for technologies that are planned for FY22. These catalog sheets are two pages and are organized by the five basic functional areas:

- Manage Tank Waste (MTW)
- Retrieve Tank Waste (RTW)
- Process Tank Waste (PTW)
- Manage Waste (MW)
- Dispose Tank Waste (DTW)

Technology needs that are identified but not planned for FY22 are listed in Section 6.0. These catalog sheets are one page and can be found in APPENDIX C.

5.1 Manage Tank Waste

The MTW functional area includes technologies to ensure that the radioactive waste liquids, salts, and sludges are maintained in a safe, regulatory-compliant manner. This includes safeguarding the overall integrity of the tanks and tank infrastructure and safely managing the waste contents. Tank farms management involves monitoring the tank contents and surrounding soil, upgrading aging infrastructure and equipment as required, providing contingency storage in the event of a tank failure, and remediating vadose zones where waste has historically leaked to the environment.

The tank farms infrastructure must also be upgraded to support the DFLAW initiative. WRPS plans to upgrade utilities, transfer lines, and support facilities to deliver LAW feed directly to the WTP LAW Vitrification Facility. Actions are being taken to support an effort that promotes modernizing and automating tank farms equipment and infrastructure to further protect tank farms workers from potential exposure to tank vapors and transition the equipment to Operations. Continued analytical support services from the 222-S Laboratory and operational support services from the 242-A Evaporator are required to achieve continued safe operations of the tank farms.

This functional area includes the following focus areas:

1. Tank Farm Operations – Improve technology related to everyday operations.
2. Vapor Programs – Modernize and automate infrastructure to further protect workers from potential exposure to vapors and general worker protection.
3. Infrastructure Integrity and Upgrades – Improve inspection techniques and upgrade utilities, transfer lines, and support facilities to deliver feed to the WTP.
4. 242-A Evaporator – Upgrade the facility as necessary to support the RPP mission and increase DST space.
5. Sampling and Transport – Confirm tank waste is within chemistry control and prepare to feed to the WTP.

This section includes the catalog sheets for near-term projects that fall under the MTW functional area.

CHIEF TECHNOLOGY OFFICE

washington river protection solutions

DST Primary Tank Bottom Volumetric Inspection

HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

Implement advanced ultrasonic testing (UT) techniques at the tank bottom to obtain quantitative data to validate the structural integrity in the bottom region of double-shell tanks (DSTs).

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

Yes

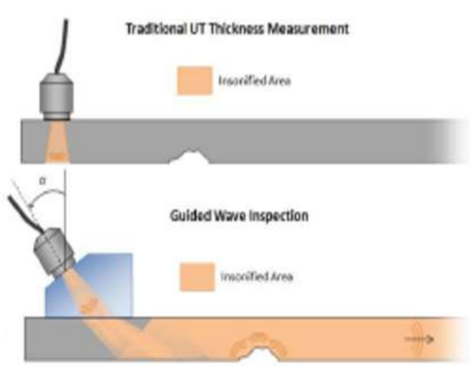
TEDS ID: MTW-11 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

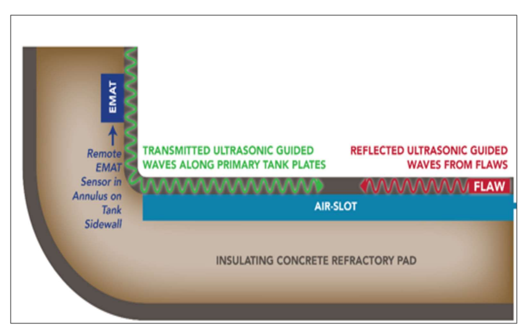
Currently, no technology is employed to quantitatively interrogate the integrity of the primary tank floor plates of the DSTs, which are physically inaccessible from the exterior of the tank and represent 90% of the tank floor. Development and deployment of such a technology would provide data to validate tank integrity through inspection of a suspect region where degradation understanding is limited.

TECHNOLOGY SOLUTION

The volumetric Ultrasonic Technology(UT) being proposed for this WRPS application falls under two categories: piezoelectric UT (shear wave, guided wave, and phased array) and electromagnetic acoustic transducers (EMAT) UT. Both methods propagate waves through the material being inspected giving data on the state of the plate as a whole rather than a single data point. The piezoelectric transducers are generally smaller and function at high frequencies. The challenge is that they require a couplant, which is often difficult for remote applications. EMAT requires no couplant because sound is generated in the part that is inspected and does not require a completely clean test surface. The challenge for EMAT is large size transducers and necessary additional signal processing.
Access to primary tank bottoms is extremely limited. Remote volumetric inspection devices, such as the EMAT, can take measurements from the annulus space by applying the EMAT to the lower portion of the primary tank wall and sending waves through the material to the bottom plates of the tank. Limitations to this inspection method are the size and location of risers as well as the impeding structures, such as pipes, in the annulus space. Inspection devices that cannot send saves through the curved knuckle of the primary tank, such as guidedwave phased array (GWPA) sensors, must couple directly to the primary tank bottom from the air-slots in the concrete refractory pad, on which the tank sits.



Piezoelectric Ultrasonic Guidedwave



EMAT Wave Propagation

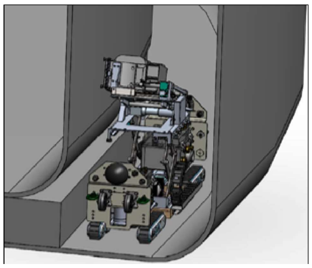
CHIEF TECHNOLOGY OFFICE

washington river protection solutions

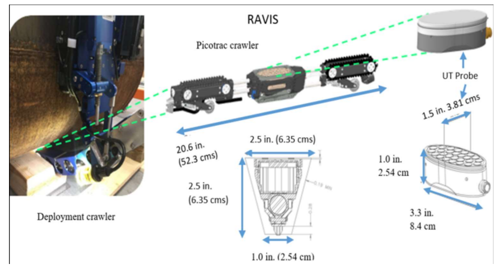
DST Primary Tank Bottom Volumetric Inspection

TEDS ID: MTW-11 Continued

ADDITIONAL TECH INFO



Remote Robotic EMAT Volumetric Inspection System (RREVIS)



Air-Slot Crawler of the Robotic Air-slot Volumetric Inspection System (RAVIS)

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $2.9M
- Insert corrosion flaws in qualification test plate for continued testing
- Order long-lead steel to extend the qualification test plate
- RAVIS GWPA sensor, Stage 2 part 2 qualification testing
- RREVIS, perform additional verification testing
- Develop Machine Learning algorithms for sensor output interpretation

FY23: $3.3M
- Fabricate Extended qualification test plate
- RAVIS GWPA sensor, Stage 3 qualification testing and verify integration between sensor and robotics
- Continue Developing Machine Learning algorithms

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Tank Failure in East Area

TFIRR-0045-T: DST Tank Failure in West Area

MEASURABLE ORGANIZATIONAL VALUE

Improves DST life expectancy through enhanced integrity monitoring.

Contractor: Kayle Boomer
Phone: (509) 372-3629
Email: kayle_d_boomer@rl.gov

DOE-ORP: Erik Nelson
Phone: (509) 372-1357
Email: Erik.Nelson@rl.doe.gov

CHIEF TECHNOLOGY OFFICE

washington river protection solutions

HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

Hanford Tank inspectons are currently performed manually by reviewing hours of video footage. Improved cameras, lighting, and automated inspection software would save time and improve accuracy of tank defect detection.

Improve Visual Inspection

TEDS ID: MTW-20 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Current video camera and lighting cannot provide the level of detail required for tank integrity inspection examination of spontaneous chemical processes and other changes that may be occurring. The current visual inspection approach involves using a time consuming manual inspection process. An improved evaluation/inspection of the recordings could reveal areas of interest for prioritizing future inspections.

TECHNOLOGY SOLUTION

Identify and test an improved video camera and lighting system, a still photography system, a data acquisition system, and a data storage system for tank integrity inspections. The video and still camera systems should, at a minimum, provide:

- Sufficient resolution and lighting to identify down to 1/16-in. cracks in the tank concrete dome using existing risers.
- A reproducible indexing system and ability to be deployed by two people (maximum) without a crane.
- Ability to take high-resolution screenshots or pictures.
- Camera lenses and other components that will survive in high temperatures and radiation

A solution to process past video records more efficiently is proposed through the use of machine learning technology which will seek to minimize the subjectivity of video analysis, decrease processing time, and improve detection of defects.

Detecting Road Pavement Deteriorization with Finite Mixture Models

Ahlberg Hi-Rod XS Camera

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Submitted As Grand Challenge?

No

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Improve Visual Inspection

TEDS ID: MTW-20 Continued

ADDITIONAL TECH INFO

Storage in the Cloud

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $568K

- Test model for recognition and qualification of flaws and develop comparative trending capability

FY23: $568K

- Test quantification capability and develop library

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Tank Failure in West Area

TFIRR-0048-T: SST Failure in West Area

TFIRR-0045-T: DST Tank Failure in East Area;

TFIRR-0047-T: SST Failure in East Area

MEASURABLE ORGANIZATIONAL VALUE

Cost savings of up to $420k/year (assuming 21 tank inspections at 200 hours per inspection); savings increase and program risk decreases as the entire process is automated and more tanks can be inspected annually.

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NEAR TERM

This technology area supports the development of tank farm vapor monitoring, detection, and remediation system technologies (equipment and software).

Technology Maturation Level

Prototype

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

Vapor Monitoring, Characterizing & Remediation

TEDS ID: MTW-24 **Timetable: > 5 Years**

TECHNOLOGY NEED

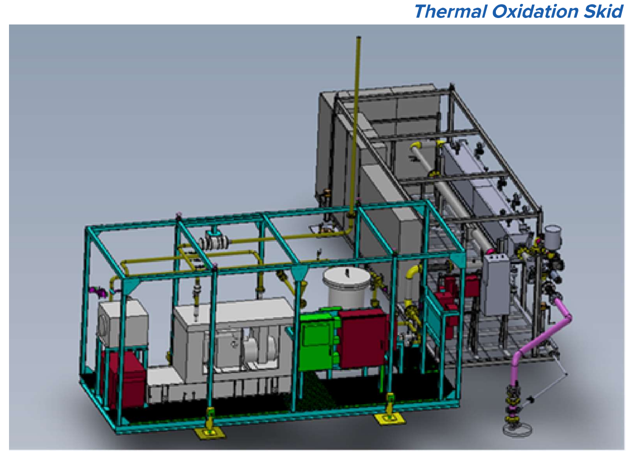
During work activities, it is desirable to quantify all known vapor sources and fugitive emissions sources and evaluate/investigate observed vapor situations, associated conditions, and provide a basis for resolution. The data/information gathered by various equipment in conjunction with dispersion modeling results supports three functional needs, namely providing: (1) a performance-based gas detection system designed to reduce risk by notifying/warning operations staff and workers during a potentially hazardous release event, (2) predictive tools for trending data analysis with dispersion modeling and forecasting events to assist work planning activities, and (3) characterization tools to describe tank farm vapor condition. In addition, there is a need to mitigate vapors via destruction and filtration.

TECHNOLOGY SOLUTION

Provide technology development to support the implementation of the recommended tank farm VMDS equipment/software. VMDS technologies include GPS (worker/equipment location); improved chemical and direct reading sensors (fixed/portable); spectroscopy monitors (ultraviolet Fourier transform infrared [UV-FTIR] stack monitor; open path Fourier transform infrared [OP-FTIR] and ultraviolet differential optical adsorption spectroscopy [UV-DOAS] area/fence line monitors); NDMA treatment; and whole-air samplers.

Fugitive Emissions Mapping Tool

Thermal Oxidation Skid



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Vapor Monitoring, Characterizing & Remediation

TEDS ID: MTW-24 Continued

ADDITIONAL TECH INFO

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY24, $2,300K
- Complete permitting, $10K
- Prepare test planning documentation, $396K
- Control System software development, testing, & documentation, $324K
- Procure materials and initiate fabrication of TOS system, $780K
- Materials and initiate fabrication of RPMS and DRE system cabinets, $376K
- Procurement documentation and work packages, $164K
- Project Management and Technical Support, $250K

FY25, $2,187K
- Complete fabrication of TOS system, FAT and NEC, $888K
- Complete fabrication of RPMS and DRE cabinets, FAT and NEC, $320K
- Package and ship TOS skids to Tank Farms. $64K
- Write/finalize work packages and lift plans, $12K

THREATS AND OPPORTUNITIES

WRPS-0003-T: Tank Vapors Controls Impact Project Execution

MEASURABLE ORGANIZATIONAL VALUE

TBD

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Tank Waste Characterization and Identification

HANFORD SITE
US DEPT OF ENERGY

TEDS ID: MTW-37 **Timetable: ≤ 5 Years**

NEAR TERM

The 222-S Laboratory employs XRD, scanning electron microscopy, polarized light microscopy and sequential leaching to identify solid phases in tank wastes. Improved instrument capabilities and sample preparation methods are needed to better identify solid and liquid phases in tank wastes and to improve ALARA considerations.

PNNL provides some additional capabilities

TECHNOLOGY NEED

Updated and new instrumentation is expected to improve routine analyses of tank wastes, infrastructure (piping, tanks, pumps), vadose zone sediments, as well as analysis of unique samples, to better support the Tank Operations Contractor (TOC) mission. Improved technologies enhance the detection and identification of liquid and solid phases and organics in tank wastes including those with short range order (e.g., nanoparticles). Instrument improvements may also aid waste processing (filtration, pumping, mixing, transfers) and support technology developments for direct-feed low-activity waste and the Low- Activity Waste Pretreatment System.

TECHNOLOGY SOLUTION

The existing x-ray diffraction (XRD) instrument includes minimal measurement and calibration capability. The desired XRD instrument incorporates dual detector technologies, point and area detectors, and multi-mode optical components and associated measurement geometries. The unique combination of these components allows for the unambiguous distinction between trace phases (currently unidentified peaks). The new XRD can also extend solid phase characterization capabilities to identify nanoparticle phases. This instrument will yield data of substantially higher resolution and statistical quality enabling the use of more advanced data analysis methods such as Rietveld refinement.
A complementary Raman micro-spectroscopy is needed to aid the identification of molecular constituents, based on vibrational frequencies of the chemical bonds and bond energies. A method of deployment is needed to use the microscopy method being developed.

The instrumentation was procured and installed at the 222-S laboratory under WRPS management. Method development for the instrument was transferred to HLMI along with 222-S laboratory management in FY21.

Infrared Microscopy

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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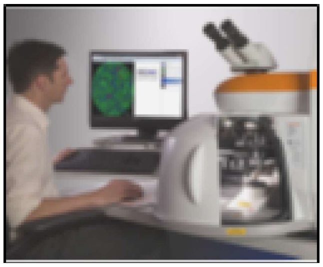
Tank Waste Characterization and Identification

TEDS ID: MTW-37 Continued

ADDITIONAL TECH INFO



Raman Microscopy

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $70K

- Method Development

FY23: $70K

- Method Development

THREATS AND OPPORTUNITIES

AAXRC-0011-T: Tank Waste Not as Expected (Different than Modeled) - Takes Longer or Cannot Be Retrieved

MEASURABLE ORGANIZATIONAL VALUE

TBD

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Analytical Method Development for Chemicals of Concern

HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

Analytical methods need to be developed, standard reference materials are needed and new instrumentation is needed to facilitate addition of COCs to the list of calibrated compounds

TEDS ID: MTW-41 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Develop methods or improve detection limits for dozens of analytes for the direct-feed low-activity waste feed qualification. The list of chemicals of concern (COCs) contains many chemicals for which there are no qualified (calibrated) analytical detection procedures. Developing new analytical methods is very time consuming and resources must be balanced against ongoing industrial hygiene analytical needs. Some compounds are never developed into calibrated procedures due to failing quality criteria too frequently or failing to pass method validation studies. Current analytical capabilities do not meet COC reporting limit needs for several compounds. Further investigation is needed to identify and adopt method improvements. Analytical conditions need to be determined for compounds where significant new separations are needed, new sampling or trapping media, or new instrumentation is needed.

TECHNOLOGY SOLUTION

Analytical method development requires more funding:

1. For staff to identify alternative sources of standard reference materials.
2. To purchase new sampling or trapping media.
3. For staff time to develop new analytical methods.
4. To test and evaluate alternative analytical methods when more appropriate than gas chromatography-mass spectrometry (GC- MS).
5. To coordinate supportive National Laboratory efforts.
6. To purchase additional instrumentation.

Method development began in FY21 on an existing HPLC system for detection of Chemicals of Concern. Continued development is expected with the procurement of new instrumentation.

High Pressure Liquid Chromotograply Instrument

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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Analytical Method Development for Chemicals of Concern

TEDS ID: MTW-41 Continued

ADDITIONAL TECH INFO

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $70K

- Instrument Evaluation and Feasibility Study

FY23: $TBD

- Next steps to be determined by the results of the Evaluation and Study

THREATS AND OPPORTUNITIES

222SL-0009-T: 222-S Laboratory Analytical Capabilities are Exceeded

MEASURABLE ORGANIZATIONAL VALUE

TBD

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NEAR TERM

A large-volume shielded sampler is needed to take 1 L samples of supernatant to support the direct-feed low-activity waste Radioactive Waste Test Platform. An improved transportation system is also needed to transport the larger samples to the laboratory

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

Large Volume Supernatant Sampler and Transportation System

TEDS ID: MTW-77 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The current tank farms approach to obtaining supernatant samples is to lower a weighted sample bottle on a wire to a required depth and collect a grab sample of 500 mL maximum (typically 250 mL). A large-volume sampler (1 L) is needed to support the River Protection Project mission, while providing improved shielding to reduce worker radiation exposure. An improved transportation system (Hedgehog III) is needed to transport the larger samples to the laboratory for analysis.

TECHNOLOGY SOLUTION

The solution proposed in this TEDS is based upon results determined by the RPP-RPT-60607 Sampling and Transportation Study. This development effort has been ongoing since 2018. Most recent efforts have focused on advancing the shielded sampler development through applying laboratory interface requirements (222-S and RPL), finalizing design and fabrication in preparation for FY21 proof of concept testing. In addition, the Hedgehog III is planned to be fully designed, fabricated and DOT7A certified by FY 22.

Hedgehog III DOT7A Sample Transport System

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Large Volume Supernatant Sampler and Transportation System

TEDS ID: MTW-77 Continued

ADDITIONAL TECH INFO

Shielded Sampler

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $219K

- Large Volume Sampler System: Complete documentation of test results
- HedgeHog III Transport Container: Complete documentation of test results

FY23

- No identified scope

THREATS AND OPPORTUNITIES

242AE-0027-T: Creation of Group A slurry Tank

AAXRC-0011-T: Waste Not as Expected (different than modeled) - Takes Longer or Cannot be Retrieived

DFLAW-0232-T: WTP Radioactive Dangerous Effluent Composition LTA

MEASURABLE ORGANIZATIONAL VALUE

Using the Large Volume Shielded Sampler technology saves about $1.145 million per sampling event, reduces collective worker radiation exposure by about 104 Rem per sampling event, and allows workers to collect up to 4 times the amount of supernatant waste in one sampling event as compared to the current baseline sampler bottle on a string. The Hedgehog III is a Department of Transportation (DOT) Specification 7A compliant transportation system that was developed specifically for transporting the larger liquid supernatant samples but could be used to transport smaller samples (both liquid and solid depending on source term) as well.

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NEAR TERM

Use robotically driven systems to autonomously deploy data collecting and monitoring detection equipment into the tank farms and demonstrate the ability to download collected information to a central docking station to communicate with the central control room.

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Submitted As Grand Challenge?

No

Reduce Entries into Tank Farms while Collecting Vapor Related Data

TEDS ID: MTW-79 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Use autonomous instrumented vehicles to reduce entries into the tank farms while collecting vapor-related data in the worker breathing zone, reducing potential exposure to the workers.

TECHNOLOGY SOLUTION

Procure an autonomously driven device already on the market and configure the instrument deployment with select vapor-related sensors. Demonstrate operation of autonomous instrumented vehicle, monitoring and collecting of data, and wireless transmission of data to a central computing system in order to scale up capabilities. Future phases will build on Phase I to further enhance worker safety and productivity by integrating additional mission needs of the company.

Husky Autonomous Instrumented Vehicle by Clearpath

WR Vector Autonomous Robotic Platform by Waypoint Robotics

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Reduce Entries into Tank Farms while Collecting Vapor Related Data

TEDS ID: MTW-79 Continued

ADDITIONAL TECH INFO

Onscreen Image of Positioning Data from the Autonomous Instrumented Vehicle

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

TBD

THREATS AND OPPORTUNITIES

WRPSC-0003: Tank Vapors Controls Impact Project Execution

MEASURABLE ORGANIZATIONAL VALUE

TBD

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Real-Time Localized Corrosion Monitoring

HANFORD SITE
US DEPT OF ENERGY

TEDS ID: MTW-87 **Timetable: ≤ 5 Years**

NEAR TERM

NanoCorrTM analyzers were developed on the basis of the coupled multi-electrode array sensor technology patented by a major international research organization and backed by several other U.S. and international pending patents. They are highly sensitive and reliable for all types of non-uniform corrosions including localized corrosions. They are also the only type of corrosion instruments in the world that have ever been claimed to be quantitative for monitoring localized corrosion below mill-per-year or micron-per-year levels.

TECHNOLOGY NEED

Currently, no technology is employed to perform real time monitoring of tank waste for localized corrosion (i.e., pitting) in the DSTs or at Effluent Treatment Facility (ETF). Development and deployment of such a technology would provide valuable information on localized corrosion in the DSTs and the ETF. An added benefit of deploying such probes in DSTs would be the ability to monitor changes in corrosion rates due to various tank operations such as waste transfers and chemistry additions to meet the new corrosion control limits. Such a technology could identify potential corrosion at the ETF during processing and allow for operational changes to minimize degradation. Recommended by the Tank Integrity Expert Panel – Corrosion Subgroup.

TECHNOLOGY SOLUTION

Recommend testing the off the shelf technology, NanoCorr system, in a laboratory environment using different waste simulants similar to what the probe would be monitoring. This testing is on-going at DNV GL and includes a stainless-steel probe to be used at ETF and a carbon steel probe to be used in the DSTs. Different waste simulants are being evaluated to test the probe and determine whether these probes should be recommended for deployment. The feasibility of field deployment at the ETF is being evaluated in FY2022. Field deployment is not yet planned but will likely be FY 2023 at the earliest.

NanoCorr Tank Corrosion Probe

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Submitted As Grand Challenge?

No

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Real-Time Localized Corrosion Monitoring

TEDS ID: MTW-87 Continued

ADDITIONAL TECH INFO

NanoCorr Analyzer

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22 $100K complete technology validation and produce a report

FY23 500K field deployment at the Effluent Treatment Facility

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Failure in West Area

TFIRR-0045-T: DST Failure in East Area

MEASURABLE ORGANIZATIONAL VALUE

TBD

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NEAR TERM

A practical repair strategy and method is needed to restore wall thickness and mitigate leaks to extend DST life and ensure existing DSTs can support the River Protection Project timeline. Successful development and use of this technology could help avoid new tank construction. Several repair methodologies have recently been screened through an evaluation process as presented in RPP-RPT-62020 Tank Repair Feasibility Study. Repair technology categories considered by the study include; process coating, solid phase processing, fusion processing and low energy repairs.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

Yes

Tank Refurbishment

TEDS ID: MTW-92 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The underground storage tanks at the Hanford Site, specifically the DSTs, are required to remain in operation for several decades beyond their original planned operating life. The DSTs are expected to provide sufficient capacity for retrieving waste from single-shell tanks for treatment and stabilization. A practical repair strategy and method is needed to restore wall thickness and mitigate leaks to extend DST life and ensure existing DSTs can support the River Protection Project timeline. Successful development and use of this technology could help avoid new tank construction.

TECHNOLOGY SOLUTION

Based on the assessment provided in RPP-RPT-62020 a three-pronged technology development approach is recommended:

1. Mature promising, purpose-driven repair technologies (e.g., repairs applicable for very large, tank bottom flaw areas such as that observed in tank 241-AY-102).
2. Develop near-term, high-maturity technologies for expedited deployment in the event of a DST leak.
3. Initiate development of long-term, proactive endeavors that support Hanford mission sustainability, with a focus on the ability to rebuild DST surfaces prior to realizing through-wall penetrations.
4. Cold spray (solid state process coating) is currently being evaluated as a viable candidate for life extension and repair of U.S. Department of Energy (DOE) complex infrastructure (e.g., double-shell tanks) critical to the Office of Environmental Management cleanup mission. Applying cold spray to the DOE complex has the potential to reduce cost and schedule impacts associated with component failures and the need to procure and construct replacement infrastructure.

Technology development success will be determined through two stages:

1. At the microscopic level to determine level of bonding and thickness formation (porosity and density) capability and effects of surface preparation, which points to favorable mechanical properties.
2. Process parameter development to include NDE assessment of a repaired section.

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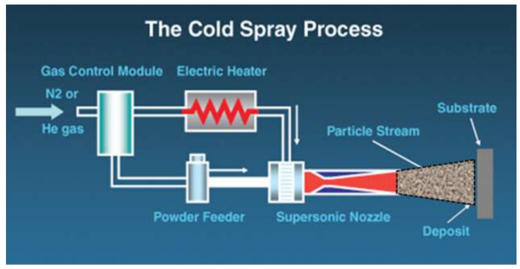
Tank Refurbishment

TEDS ID: MTW-92 Continued

ADDITIONAL TECH INFO



PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $1,100K
- Cold Spray Process - Development of deployment method and demonstration

FY23: $1,100K
- Polymer Grout - Parameter Development and Phase 2 Demonstration
- Cold Spray Process - Continue development of deployment method and demostration

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Tank Failure in West Area

TFIRR-0045-T: DST Tank Failure in East Area

MEASURABLE ORGANIZATIONAL VALUE

To simplify MOV it will use toolbox costs against a single case of AY-102 brought back into service for emergency storage of supernate. This calculation utilizes the total cost of the toolbox, which is expected to take $35M and completed over three to nine years. The total expected benefit is captured in not requiring the construction of a new tank, estimated at $200M based off project estimate in (WHC-SD-W236-CDR-001) divided into a single tank construction and adjusted for inflation. The ROI generated using these values is 471%.

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Internal Data Access & Visualization (IDAV)

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NEAR TERM

Web-based application that provides IH users with access to historical and current vapor sampling and monitoring data. The application would provide intuitive tools for data analysis, exposure assessments, supporting development of hazard controls. The application also provides tools for visualizing and analyzing data from personal ammonia monitors and Gastronics fixed instrument skids.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

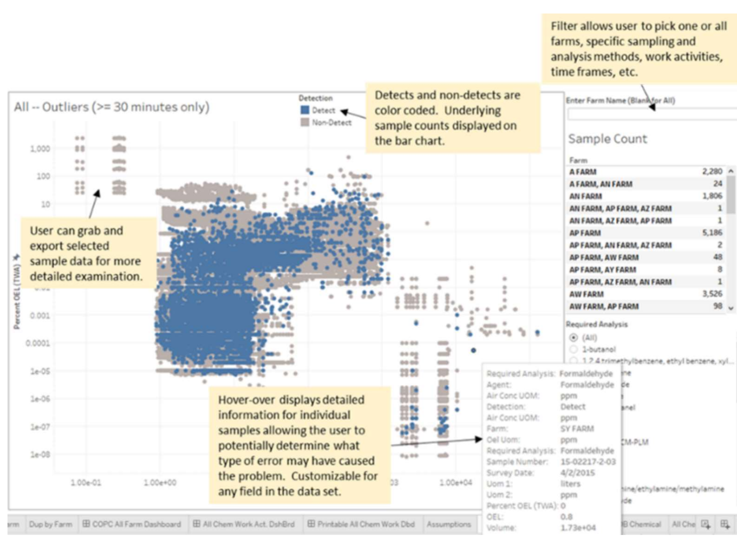
TEDS ID: MTW-94 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Tank Operations Contractor Industrial Hygiene (IH) conducts tank farm worker hazard exposure assessments to identify, evaluate, and recommend controls, and other worker protection measures for tank farm chemical, physical, and biological hazards. The current IH database, involving tens of thousands of records, is a manual process. The IH vapor data varies widely in its scope and quality, containing errors from sampling and analysis issues, transcription, unit transposition, and inconsistent data collection. IH analysis and exposure assessments are time consuming and human resource intensive.

TECHNOLOGY SOLUTION

Model, build, and develop a web-based application that automates IH tank farm worker vapor, chemical, and biological exposure assessments, data collection, analysis, and visualization processes. The system would provide users with access to historical and current vapor sampling and monitoring results, intuitive tools for data analysis, exposure assessments, and IH evaluation supporting development of hazard controls. The system would be automated, providing scalable analysis process, defensible results, and improved quality.



Error Detection and Outlier Analysis (OEL Basis)

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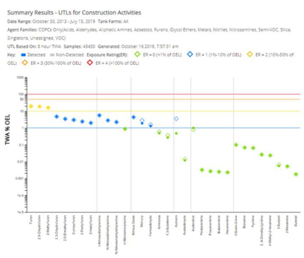
Internal Data Access & Visualization (IDAV)

TEDS ID: MTW-94 Continued

ADDITIONAL TECH INFO



Upper Tol Limit Summary Results by Work Activity (Const in AX Farm)

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22 $1652K

- IDAV and Tableau Tools Development and Testing

FY23 $1678K

- IDAV and Tableau Tools Development and Testing

THREATS AND OPPORTUNITIES

MEASURABLE ORGANIZATIONAL VALUE

TBD

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US DEPT OF ENERGY

NEAR TERM

The DFAS, powered by the AECOM SmartSite software platform, compiles vast amounts of dynamic data and delivers it in an easily understandable dashboard monitor.

Predicting Tank Farm Vapor Conditions

TEDS ID: MTW-95 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Develop an integration of real-time vapor and meteorological data to predict tank farm vapor conditions (i.e., plume location or transient vapor concentrations) in the tank farm work areas. The Data Fusion and Advisory System (DFAS) is 1 of the 15 technologies identified during the Chemical Vapors Solutions Team (CVST) evaluations included the use of a chemical vapor release and response software system to gather and assimilate real-time data from detection/monitoring technologies (new and existing) to predict tank farm vapor-related conditions. A goal of this integrated system is to develop means to predict potential exposure scenarios and establish preemptive mitigating actions.

TECHNOLOGY SOLUTION

The DFAS will be able to correlate data from the multiple vapor sources and other vapor-related instruments, allowing users to study the factors present when the field conditions change in real time. The system will allow Hanford tank farms central shift office staff and field workers to track and trend vapor source data and to potentially predict future vapor source concentrations and weather conditions in work spaces and locations based on historical and real-time field-based data. Dashboard graphics will provide an at-a-glance indications of data to assess current conditions and potential risks.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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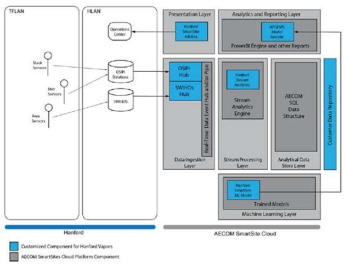
Predicting Tank Farm Vapor Conditions

TEDS ID: MTW-95 Continued

ADDITIONAL TECH INFO



SmartSite Solution Components

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $115K

- Expansion within Vapors program

FY23: $560K

- Supplemental Plume Modeling Development
- Predictive Modeling Development

THREATS AND OPPORTUNITIES

WRPSC-0003-T: Tank Vapors Controls Impact Project Execution

MEASURABLE ORGANIZATIONAL VALUE

The data fusion & advisory system will save ~ $950,000 over 5 years, save ~7,100 hours per year of daily work planning, and help workers avoid 3 days of hazardous vapor exposure annually.

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5.2 Retrieve Tank Waste

The waste retrieval functional area is required to remove most of the waste to close the tanks per regulatory requirements. Retrieval efficiency is based on knowledge of the tank contents for the extraction of the waste with effective tools, the transfers downstream, and the mixing and blending for delivery of feed to the WTP that meets waste form qualification requirements. Across all aspects of the waste retrieval process, there is a need-to-know overall waste composition, and chemical and physical characteristics. Remote in situ monitoring of these parameters would enhance and improve retrieval operations. The waste retrieval function can also include special processes such as those envisioned for contact-handled transuranic (CH-TRU) waste and mitigation of selected DSTs.

The various methods of waste retrieval are described in RPP-RPT-44139, *Nuclear Waste Tank Retrieval Technology Review and Roadmap* as well as RPP-PLAN-40145, *Single-Shell Tank Retrieval Plan*. Modified sluicing or salt cake dissolution is typically used to retrieve the majority of the waste volume from the SSTs; however, these methods are typically insufficient to reach the established residual waste volume goal of 360 ft^3 or less for 100-series SSTs, and 30 ft^3 or less for 200-series SSTs as mandated by the Tri-Party Agreement. This residual waste is typically characterized as a hard heel of insoluble material that requires more aggressive methods to mobilize and remove from the tank. The TOC also uses mechanical and chemical technologies for hard heel removal subsequent to waste retrieval operations using modified sluicing.

Implementing these technologies can require tank modifications in the form of new or larger tank penetrations to accommodate waste retrieval equipment. The RTW functional area includes the following focus areas:

1. Retrievals – Characterization of the SST waste is a first step in successful mobilization and retrieval of the tank waste. Multiple techniques are required to mobilize and retrieve the SST waste to the level needed for ultimate closure of tanks.
2. DST Transfers – The DST waste transfer system is a critical, interdependent system within the RPP that relies on the ability to continually retrieve, treat, and transfer tank waste to the LAW Pretreatment System (LAWPS), WTP, and various waste treatment facilities. The near-term DST waste transfer strategy focuses on startup, commissioning, and initial operation of LAWPS, waste volume management, and modeling of waste blending and staging strategies.
3. Cross-Site Transfers – Important technology considerations for cross-site transfer lines are leak detection, line plugging detection and clearing capability, and critical velocity measurement.
4. DST Upgrades – A primary objective of DST upgrades is to ensure that the Hanford Site tank farms are able to provide optimized, continuous, and reliable feed to the WTP or new supplemental treatment systems.
5. Feed Preparation – The primary goal of feed preparation is to ensure that qualified waste feed batches are readily available for WTP and secondary treatment system campaigns.
6. Tank Closures – The ultimate RPP mission goal is to close the waste tanks and associated waste management areas.

This section includes the catalog sheets for the near-term technologies that fall under the RTW functional area.

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Retrieval and Closure Solid Waste Sampling Tools

HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

Develop, design, build or modify solid waste sampling tools such as the existing ORSS and the extended finger trap.

TEDS ID: RTW-01 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Improved tank waste sampling tools are necessary for the following:

1. Verification of tank closure standards.
2. Simulant development for testing new retrieval technologies.
3. Development of technologies targeted to specific tank waste retrievals.

Current sampling technologies do not fully address the aforementioned needs due to tank access limitations and inability to collect representative samples.

TECHNOLOGY SOLUTION

The first technology development effort involves modification of the existing off-riser sampling system (ORSS) to address inadequacies based on previous deployments. The second effort involves locating a replacement for the current ORSS. The first two efforts are currently unfunded. The third effort involves modification of an existing design to collect solids known as the finger trap sampler. Modification includes lengthening the sample chamber and improving the deployment to include off-riser capability.

Reference: RPP-18793, Performance Speciftcation for the Off-Riser Sampling System (ORSS}

Current ORSS - General Electric Inspection Technology (GEIT) V3020-6310 Crawler and V9500-4001 Sample

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Submitted As Grand Challenge?

No

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Retrieval and Closure Solid Waste Sampling Tools

TEDS ID: RTW-01 Continued

ADDITIONAL TECH INFO

Push Mode Core Sampling Device

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY23: $144K

- Investigate ORSS replacement system

FY24: $436K

- Procure identified replacement

THREATS AND OPPORTUNITIES

AAXRC-0011-T: Waste Not as Expected (different than modeled) - Takes Longer or Cannot be Retrieved

MEASURABLE ORGANIZATIONAL VALUE

~$100K savings per sampling event.

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Residual Volume Measurement System (RVMS)

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TEDS ID: RTW-02 **Timetable: ≤ 5 Years**

NEAR TERM

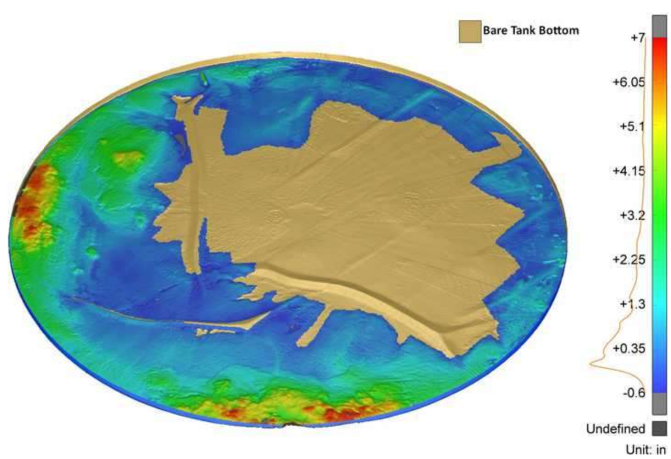
The previous RVMS that the Tank Operations Contractor used was limited by the size of the system (12-in. risers only}. The current system was recently deployed for deployment in a 6-in. riser. Smaller technology is needed to access the more available 4-in. risers on single-shell tanks.

TECHNOLOGY NEED

Accessibility to 12-in. and 6-in. risers is limited; therefore, a system deployable down 4-in. risers is needed as they are more accessible. The current limitation is the laser scanner itself, which cannot fit down a 4- in. riser. The ability to deploy down 4-in. risers provides flexibility in deployment locations ensuring ideal positioning for single or multiple location scans. This is essential when in-tank equipment would otherwise obstruct the scanner's view from a single riser. In addition, the existing RVMS, the sole tool used to determine residual waste volumes, was recently deployed to aide in tank dome condition inspections. This was a new use case not previously considered, further justifying the need.

TECHNOLOGY SOLUTION

A laser scanner small enough to fit down a 4-in. riser has been procured. Testing with the current RVMS deployment device still needs to be performed.



Depth of the waste remaining in AX-102 after 2nd retrieval technology was used

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Submitted As Grand Challenge?

No

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Residual Volume Measurement System (RVMS)

TEDS ID: RTW-02 Continued

ADDITIONAL TECH INFO

4-in Capable Laser Scanner

6-in Capable Laser Scanner

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $166K

- Investigate 4in riser capable unit

FY23:-

- No identified scope

THREATS AND OPPORTUNITIES

AAXRC-051-T: Equipment in Risers is more difficult to remove than anticipated

MEASURABLE ORGANIZATIONAL VALUE

Free up 12 inch tank risers for Retrieval Operations

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NEAR TERM

Improve the life expectancy of hose-in- hose transfer lines through testing that encompasses all the degradation mechanisms experienced in the fteld and uses the entire hose assembly. Completion of this scope will provide monetary savings and also reduces worker exposure to dose from the waste as replacement of the hoses becomes less frequent.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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Evaluation of Hose-in-Hose Transfer Line (HIHTL) Material Properties

TEDS ID: RTW-10 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

All WRPS retrieval technologies use in tank pumps to transfer radioactive tank waste. Waste slurry is pumped from the single shell tanks through rubber hose in hose transfer lines (HIHTL) to valve boxes for re-routing the waste to the double-shell tanks. The effective service life of the HIHTLs is a function of the EPDM and the polyester reinforcement braiding resistance to the chemicals and radiological exposure form the tank waste in conjunction with the effects of operating degradation mechanism, such as temperature and pressure. The HIHTL lifetimes are set to ensure hose integrity during the forecasted operation time but the calculated life expectancies are only as good as the degradation testing inputs. Due to the complexity of degradation mechanisms for the radioactive waste these calculated life expectancies have been conservatively shortened since material testing using actual Hanford Site waste is difficult and typically published data does not combine both chemical and radiation exposure with the operating degradation mechanisms. Testing that combines the chemical and radiological degradation mechanisms along with the in field temperature and pressure exposure is needed to better predict the HIHTL service life.

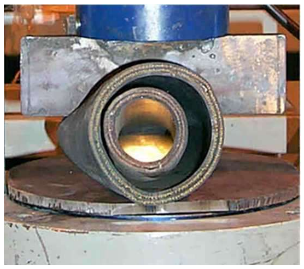
TECHNOLOGY SOLUTION

The development approach includes preparation of specifications and a statement of work to award a contract with Florida International University {FIU} for the testing of the materials used in hoses and the hose assemblies themselves. The research includes testing to meet the physical requirements {e.g., pressure, flexibility, temperature} of the hoses and also determines the chemical and radiological degradation.

A current result of this work has been the successful implementation of testing performed at Savannah River National Laboratory {SRNL} and involved characterizing burst strength decay of hoses relative to radiation exposure. Although the hoses used in the SRNL study were similar to, but not identical to the hoses used at Hanford, the information gained was successfully applied to the hoses used on the Hanford Site increasing the maximum acceptable radiation exposure from 10 Mrad to 50 Mrad.

Current testing is focused on the chemical degradation from the waste{FIU} and the combined degradation

ADDITIONAL TECH INFO



PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

TBD

THREATS AND OPPORTUNITIES

AAXRC-0024-T: Waste Temperatures Exceed HIH Limits

MEASURABLE ORGANIZATIONAL VALUE

TBD

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NEAR TERM

Technology for drilling multiple enlarged holes in tank domes for risers up to 4 ft in diameter is in the design phase. Research, design, and development of the cutting system will ensure the dome cores are removed utilizing governing safety criteria. Factory and onsite acceptance testing will be performed prior to deployment of a ftnal system.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Submitted As Grand Challenge?

No

Development of New Riser Installation System

TEDS ID: RTW-12 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

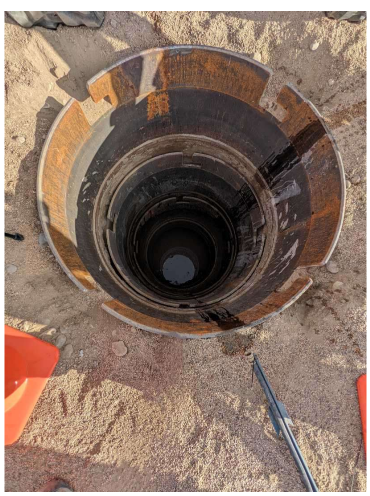
The goal of this work is to develop a method that is safer for tank farm personnel, is more efficient, and is more cost-effective to implement than previous core cutting efforts. In addition, hard to access risers and pits no longer need to be used for retrieval (e.g., tank C-105}. The rotary core cutting system will provide more efficient core cutting in the tank domes. Core cutting will support future work of installing new risers for tank waste retrieval, which will minimize the need to remove existing equipment and allow installation of and additional access for other new retrieval equipment.

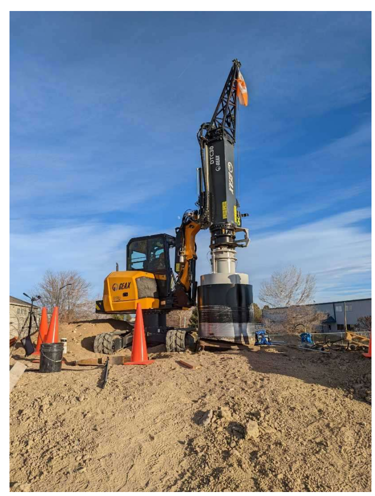
TECHNOLOGY SOLUTION

The development approach: Awarded contract with a commercial vendor for the development and testing of a mobile rotary core drilling system that is capable of core drilling (48 in.) holes in the dome of single-shell tanks in preparation of future riser installation. Based on successful development and testing, a prototype system was designed, fabricated, and will be delivered to the Hanford Site.

The new Tank Dome Core Cutter is a mobile rotary core drilling system. It cuts through existing soil cover and SST concrete domes enabling installation of new SST risers (48 inch diameter).

The system is comprised of a DTC30 (limited access drill rig) base, stack caissons, core cutting drill bit and soil removal tool, core and pilot drill. The A and AX Tank Farm tanks are the next planned to be retrieved. Obstructions in these tanks make waste retrieval challenging. In addition to normal piping, pumps, other components, and materials left in the tank, the tanks were designed with air lift circulators (pipes extending from the dome to the bottom of the tanks} that present congestion for retrieval efforts, camera observation, and lighting.





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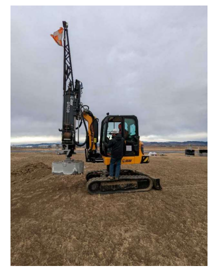
Development of New Riser Installation System

TEDS ID: RTW-12 Continued

ADDITIONAL TECH INFO

Core retention in core bit. Left: start of cut. Right: end of cut.

Core retention in core bit. Left: start of cut. Right: end of cut



TDCCS with Soil Removal Attachment

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $936K

- Test Facility Construction

-Test driven improvements

- Delivery of Prototype

FY23

- Scope complete

THREATS AND OPPORTUNITIES

AAXRC-0043-T: Equipment in Risers is more Difficult to Remove than Anticpated

AAXRC-0051-T: Damage to Tank/Equipment Installation or Removal

MEASURABLE ORGANIZATIONAL VALUE

Using the New Riser Installation System about $853,000 will be saved per riser installation, meaning the New Riser Installation System will pay for itself in roughly 3 riser installations. By developing and implementing the New Riser Installation System, the amount of worker radiation exposure per installation is cut in half and risers can be installed 25 days faster than with the current technology.

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US DEPT OF ENERGY

Low Volume Addition Retrieval

TEDS ID: RTW-55 **Timetable: ≤ 5 Years**

NEAR TERM

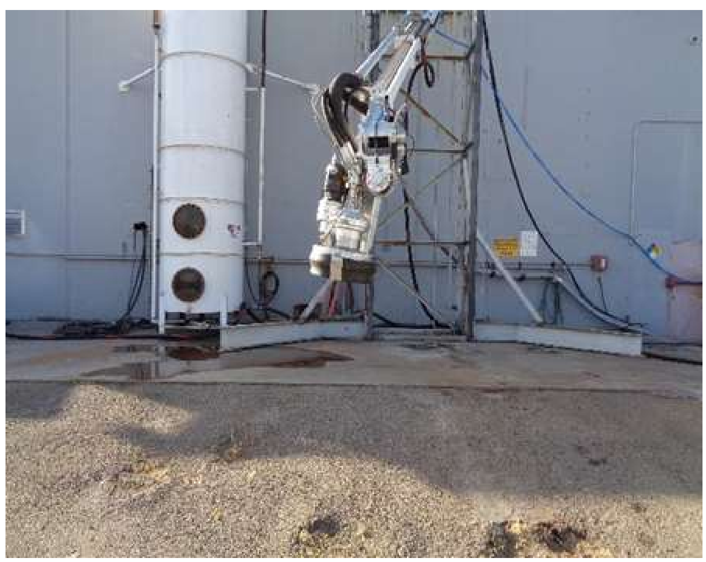
A modified version of previous a retrieval technology is being developed for unique Hanford Site retrieval scenarios. The previous version was deployed on a crawler; this version is being combined with an Extend Reach Sluicer to maximize resources. The Full implementation of this would result in a deployed Hanford Waste End Effector (HWEE) retrieval system.

TECHNOLOGY NEED

Existing sluicer technology requires excessive water consumption leading to increased waste volumes. The HWEE was proven to be more efficient (i.e. less water consumption) than the Extended Reach Sluicing System (ERSS) in simulated waste testing.

TECHNOLOGY SOLUTION

Phase I: HWEE End Effector Development – End Effector Down Select, identifying a confined sluicer to optimize water usage during retrieval. This was completed in fiscal year (FY) 2017. -Phase II: HWEE Advanced Functional Testing –End effector positioning, and effectiveness demonstration. Includes conveyance-testing, development of end effector positioning, including the ability to avoid expected obstructions in an SST; and demonstrate the effectiveness of the integrated HWEE system. This was completed in fiscal year FY 2018. -Phase III: HWEE adaptation to an ERSS articulated mast with functional test by vendor FY 2019. -Phase IV: Rebuild HWEE and perform functional cold test at HiLine with articulated mast using simulant with emphasis on conveyance capability FY 2022.



HWEE attached to ERSS Arm

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Submitted As Grand Challenge?

Yes

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Low Volume Addition Retrieval

TEDS ID: RTW-55 Continued

ADDITIONAL TECH INFO

FY19 Functional test

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22

Task 1 Disassemble HWEE-ERSS and perform HWEE repair, 2 months, $86,951.71

Task 2 Functional/Pressure Testing of the repaired HWEE and reattach to the ERSS 1 month, $42.355.64

Task 3 Perform functional integrated test with simulant of the repaired HWEE, 2 months, $279,820.24

THREATS AND OPPORTUNITIES

AAXRC-0012-T: Delays in A-104 and A-105 Retrieval Due to Technology Development

MEASURABLE ORGANIZATIONAL VALUE

It is possible the HWEE is up to 10 times faster and has a dilution ratio that is 20 times more efficient than traditional sluicing methods. The HWEE uses at least 6 times less water, which translates to upwards of $4 per gallon in the evaporator saved. The HWEE only requires about 1/4 of the time previous sluicing methods took, which translates to cost saved from labor.

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5.3 Process Tank Waste

The PTW functional area focuses on methods through which Hanford Site tank wastes must be retrieved from the tank farms and safely immobilized into stable waste forms for disposal. The baseline method for Hanford Site waste immobilization is vitrification. As part of the WTP design basis, the retrieved waste will be separated into LAW and high-level waste (HLW) fractions. The HLW fraction of the waste will be vitrified into borosilicate glass at the WTP HLW Vitrification Facility and some of the LAW will be vitrified into borosilicate glass at the WTP LAW Vitrification Facility. The LAW Vitrification Facility alone was never intended to treat the entire inventory of Hanford Site LAW in the same period as the HLW can be treated. Supplemental immobilization was proposed to treat part of the LAW (ORP-11242). The proposal was based on use of the minimum requirements in the WTP Contract assumed to be the basis of the full capability of the plant. Technologies that have been considered for immobilization include joule-heated melter vitrification (similar to WTP), grout (cast stone), fluidized bed steam reforming, and bulk vitrification. However, the scope of the supplemental immobilization and treatment projects have been deferred until a date yet to be determined and the final decision will require both programmatic and regulatory review. The scope of these projects will be made after the startup of DFLAW operations. The need for supplemental LAW capacity and its nature are indeterminate. Therefore, additional supplemental treatment technology elements will be added after that decision is made.

The TOC is committed to providing support for startup of the LAW Vitrification Facility by designing and deploying the DFLAW pretreatment facilities that will enable early facility startup.

As the RPP mission transitions from managing and retrieving tank farms to waste treatment operations, the need exists to understand the flowsheet interactions that may occur and to anticipate the implications this interconnectedness may cause with respect to chemical interactions, process flows, unit operations, and effluent management. The RPP mission is examined holistically to develop integrated process flowsheets from the individual process flowsheets that comprise each aspect of the RPP mission. The portions of RPP-RPT-57991, *One System River Protection Project Integrated Flowsheet*, that are of greatest importance for the scope of the Roadmap are those that directly impact the tank farms and future waste treatment support of DFLAW.

The PTW functional area includes the following focus areas:

1. DFLAW Pretreatment Operations – Uses filtration to remove suspended solids containing alpha-emitting TRU nuclides and highly radioactive strontium 90, and ion exchange (IX) using crystalline silicotitanate (CST) resin to remove cesium 137 from supernatant tank waste.
2. Effluent Management Facility (EMF) – During DFLAW operations, evaporation will be performed in the planned EMF. The volatile and corrosive halide and sulfate components are highly concentrated in this stream because they are volatile at melter operating temperatures.
3. WTP LAW – The LAW Vitrification Facility has been designed to vitrify LAW into borosilicate waste glass using a joule-heated, ceramic-lined melter system. That facility will generate a substantial volume (i.e., millions of gallons per year) of liquid secondary waste (LSW) from the off-gas treatment system.

4. WTP HLW – The HLW Vitrification Facility has been designed to vitrify HLW into borosilicate waste glass using a joule-heated, ceramic melter system.
5. Tank Waste Characterization and Staging – Provide a compatibility bridge between sludge wastes stored in the tank farms and the WTP receipt systems to ensure delivered waste is within the WTP waste acceptance criteria.
6. CH-TRU Tank Waste – Current assumptions are that 11 SSTs containing CH-TRU tank waste will be treated at a supplemental TRU treatment facility and then stored onsite at the Central Waste Complex until final disposition is determined.

This section includes the catalog sheets for the near-term technologies that fall under the PTW functional area.

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Methods for Mitigating DFLAW Flowsheet Gaps

TEDS ID: PTW-23 **Timetable: > 5 Years**

NEAR TERM

Laboratory and engineering-scale testing will be conducted to assess alternative processing technologies for various EMF feed and eff/uent streams. This work will address gaps in the baseline DFLAW flowsheet on partitioning and treatment of key COCs, determine if the WTP liquid eff/uent sent to the LERF/ETF will meet ETF WAC for delisting organics, evaluate the opportunity to purge the EMF bottoms and redirect to an alternate disposal path, and address recycle risks.

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

TECHNOLOGY NEED

Technology development and maturation activities are needed to address limitations in Waste Treatment and Immobilization Plant (WTP) operations caused by the Effluent Management Facility (EMF). This includes laboratory and pilot scale tests to:

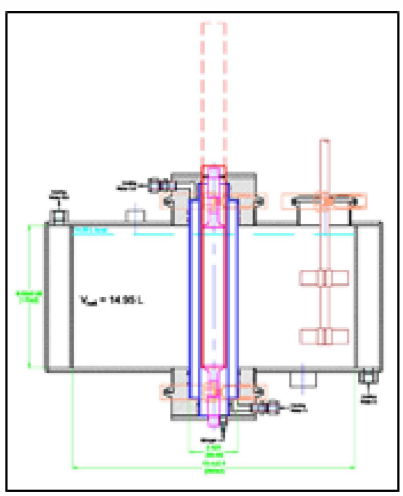
1. Address gaps in direct-feed low-activity waste (DFLAW) flowsheet on partitioning of key chemicals of concern (COCs) Tc-99, I-129, Hg, and organics within the melter and off-gas treatment system.
2. Determine if the liquid effluent from the WTP sent to the Liquid Effluent Treatment Facility (LERF)/ Effluent Treatment Facility (ETF) will meet ETF waste acceptance criteria (WAC).
3. Identify and develop solutions for COCs that exceed the LERF/ETF WAC or other regulatory requirements.
4. Demonstrate the efficacy of purging EMF bottoms to alternate disposal path to increase DFLAW throughput, reduce immobilized low-activity waste (ILAW) container count, and free space in double-shell tanks.
5. Address risk associated with high sulfate and high halide concentration in EMF bottoms recycle, fluctuations in the waste feed composition, reduction in waste loading/increased ILAW glass container count.

TECHNOLOGY SOLUTION

Laboratory and engineering scale testing will be completed to address project uncertainties associated with the partitioning and speciation of organics, 99-Tc, 129-I, and Hg in within the WTP melter and off-gas system to identify possible risks to meeting the LERF/ETF regulatory requirements. Mitigation strategies will subsequently be developed and test for these risk areas.

Key activities to support this include:

- Develop and test iodine removal media and reactor technologies capable of targeting the species of iodine observed in FY 2019 tests in the caustic scrubber liquids and EMF evaporator overheads.
- Evaluate extent of the natural potential for biological activity in the LERF basin to reduce the concentration of organics in WTP liquid effluent.



Laboratory-scale UV light reactor for organic destruction

Methods for Mitigating DFLAW Flowsheet Gaps

TEDS ID: PTW-23 Continued

ADDITIONAL TECH INFO

Packed columns to test removal of COCs from aqueous media

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $760K
- Aqueous Iodine Removal: address uncertainties in design basis
- Address Flowsheet gaps

FY23: $939K
- Aqueous Iodine Removal: Scale –up testing

THREATS AND OPPORTUNITIES

DFLAW-0401-O: Alternative Treat/Dispose Path for EMF Evaporator Concentrate

DFLAW-0232-T: WTP Radioactive Dangerous Liquid Effluent Composition LTA

MEASURABLE ORGANIZATIONAL VALUE

~22% increase throughput; reduce container count (~8,300); increase available DST space.

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Radioactive Waste Test Platform

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TEDS ID: PTW-38 **Timetable: ≤ 5 Years**

NEAR TERM

Develop and operate test Platform that will provide bench scale unit operations for DFLAW. Capability for troubleshooting, waste feed qualification data, check new unit operations, and close flowsheet gaps. Future capabilities include: - Understand specific tank chemistry with individual unit operations –HLW sludge and CST melts –Tank batch qualifications for CST usage – increase waste loadings for glass –opportunistic samples (after decontamination – any new unit operation validation and design input.

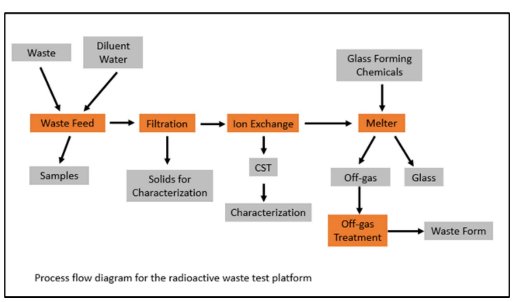
TECHNOLOGY NEED

Provide a test platform that supports unit operations trouble shooting, waste feed qualifications, flowsheet validation, and TSCR design input. Support waste form development and confirm design inputs for EMF bottoms. Provide unit operations trouble shooting. Support for waste feed qualifications and flowsheet validation.

TECHNOLOGY SOLUTION

A test platform is needed to address flowsheet gaps and inform future direct-feed LAW (DFLAW) operations. A scaled test platform will enable completion of the following tasks: waste feed preparation, filtration, ion exchange, solid waste form production and melter condensate recycle. The platform is intended to contribute to both LAW and HLW treatment.

Future applications include:
- Understand specific tank chemistry with individual unit operations
- Inform production operations-
- Process troubleshooting and evaluation-
- High-level waste sludge and crystalline silicotitanate (CST) melts
- Tank batch qualifications for CST usage
- Increase waste loadings for glass-
- Opportunistic samples (after decontamination)
- Any new operation validation and design input.



Process Flow Diagram for the Radioactive Waste Test Platform

Hot Cell

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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Radioactive Waste Test Platform

TEDS ID: PTW-38 Continued

ADDITIONAL TECH INFO

Cells Unit Filter

Melter

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22:$3,135K
- Filter waste at tank temperature
- Run waste through IX at safey basis temperature and tank temperature
- Run waste through Melter
- Continue storage studies of spent CST
- FY22 tasks to include AP 101 waste

FY23: $3,135K
- Filter waste at tank temperature
- Run waste through IX at safety basis temperature and tank temperature
- Run waste through Melter
- Continue storage studies of spent CST
- FY23 tasks to include AP 105 waste

THREATS AND OPPORTUNITIES

DFLAW-1148-T: TSCR Solids Filtration Throughput LTA

DFLAW-1095-T: TSCR and WFD Systems Unable to Meet WTP Feed Demand during Operations

DFLAW-0106-T: Staged Treated LAW Feed to WRTP Does Not Meet Waste Acceptance Criteria for Cesium-137

MEASURABLE ORGANIZATIONAL VALUE

TBD

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NEAR TERM

Technology solutions are needed to provide the resources and capabilities for rapidly resolving DFLAW operational issues

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

DFLAW Process Operational Troubleshooting

TEDS ID: PTW-53 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Lessons learned from other DOE operations have shown significant delays that result from process upsets. And/or significant variations from flow sheet projections. To mitigate delays, technologies are needed to provide troubleshooting capabilities and reduce risks to commissioning, startup, and operations. Areas of operational uncertainty include, but are not limited to, waste feed pretreatment, glass former reliability, melter capability, foaming control, offgas treatment, and secondary waste management.

TECHNOLOGY SOLUTION

Technology development required to provide troubleshooting capabilities to mitigate uncertainty include the following:

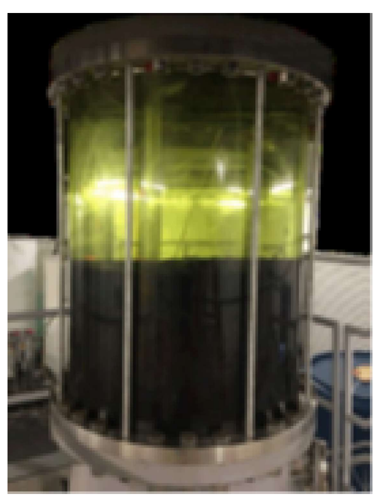
Task 1: Maintain radioactive and nonradioactive test facilities (i.e., radioactive waste test platform) to support pretreatment filtration and ion exchange, which were developed as part of PTW-38.

Task 2: Provide and maintain melter/headspace and offgas treatment train (e.g., submerged bed scrubber, wet electrostatic precipitator, other elements) testing capability to gain operational assurance. This equipment should allow for rapid troubleshooting of startup and operational problems.

Task 3: Evaluate the need for and develop testing facilities to manage secondary waste formulation and handling.

Task 4: Identify and evaluate direct-feed low-activity waste (DFLAW) process issues and conduct testing to determine mitigation strategy (e.g., foam control).

Task 5: Identify and evaluate DFLAW mechanical issues and conduct testing to determine mitigation strategy (e.g., agitator).



Ion Exchange Test

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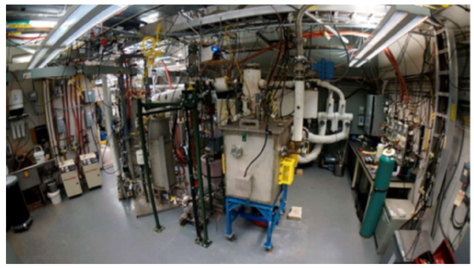
DFLAW Process Operational Troubleshooting

TEDS ID: PTW-53 Continued

ADDITIONAL TECH INFO



DM10 - Scale Melter at Vitreous State Laboratory

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FYTBD: $3,200K
Provide pilot-scale melter/off-gas system

FYTBD: $4,950K
Provide pilot-scale melter/off-gas system

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

MEASURABLE ORGANIZATIONAL VALUE

TBD

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Chemical Process Modeling Software to Support DFLAW Operations

HANFORD SITE
US DEPT OF ENERGY

TEDS ID: PTW-55 **Timetable: ≤ 5 Years**

NEAR TERM

Design and develop dynamic chemical process modeling capabilities to aid in operational flow sheeting of Tank Side Cesium Removal (TSCR), Effluent Treatment Facility (ETF) and Waste Treatment and Immobilization Plant (WTP) operations.

TECHNOLOGY NEED

RPP-44491 identifies the need for operational flow sheeting software that is dynamic, uses a rigorous thermodynamic database, is supported commercially and contains an accurate representation of Waste Treatment and Immobilization Plant (WTP) operating logic so that transient behavior is predicted correctly. This has been expanded to include the need for a dynamic chemical process model of tank-side cesium removal (TSCR) and the Effluent Treatment Facility (ETF).

TECHNOLOGY SOLUTION

Development of the gPROMS WTP Model began in earnest after the release of the Operation Readiness Evaluation. A usable model exists today, including modifications to the facility for direct-feed low-activity waste (DFLAW) operations and the addition of the Effluent Management Facility (EMF). Model maintenance and updates to make the model more robust and to shift it from a planning tool to an operations tool will be needed each year, especially as the facility is started up and operational experience is gained.

Models of both the TSCR capability and the ETF have also been completed. The TSCR model will continue to be maintained and updated as operations strategies are developed and sample data is taken that can be used to verify the validity of the model. Additionally, updates are planned as more information is made available from laboratory experiments involving crystalline silicotitanate (CST). The ETF model will also be maintained and updated as changes to the facility design are chosen and implemented, new sample data is received, and operational experience with the new WTP effluent waste stream is gained.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

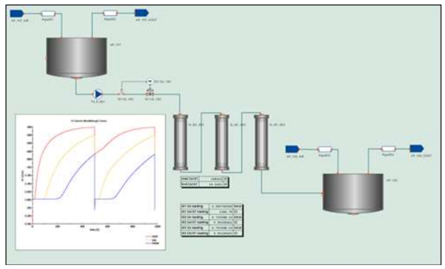
Submitted As Grand Challenge?

No

Chemical Process Modeling Software to Support DFLAW Operations

TEDS ID: PTW-55 Continued

ADDITIONAL TECH INFO



TSCR Process Schematic Example

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $300K

- gPROMS Model Updates

FY23: $300K

- gPROMS Model Updates

THREATS AND OPPORTUNITIES

DFLAW-0232-T: WTP Radioactive Dangerous Liquid Effluent Composition LTA

DFLAW-0106-T: Staged Treated LAW Feed to WTP Does Not Meet Waste Acceptance Criteria for Cesium-137

DFLAW-0075-T: Secondary Liquid Waste Volumes are Higher than Expected

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

MEASURABLE ORGANIZATIONAL VALUE

TBD

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5.4 Manage Waste

Hanford Site waste immobilization processes will generate secondary waste byproducts in addition to canistered waste forms. Safe, effective disposal paths must be provided for the secondary waste byproducts. The appropriate disposal path will be determined based on the nature of the waste type (i.e., LSW or SSW).

Secondary Solid Waste (SSW) may be disposed using a variety of different methods, depending on the type, size, and level of contamination of the waste. SSWs (i.e., radioactive solid wastes) are non-liquid waste debris and byproducts of Hanford Site operations. The different SSW types include miscellaneous failed equipment, filters; debris; spent IX media; failed LAW melters; LAW melter consumables (e.g., bubblers, thermocouples); and glass residues, among others. Some SSW may be treated on or offsite and are planned to primarily be disposed of at the IDF.

The WTP HLW and LAW Facilities will convert radioactive wastes into glass. Vitrification is a high-temperature process. As a result of WTP vitrification, a portion of the volatile species in the waste (e.g., fluorides, chlorides, some radionuclides [technetium]) will partition to the off-gas system and become part of the LSW streams. In the DFLAW configuration, LAW vitrification will generate off-gas condensates that will be concentrated by evaporation at the EMF. The concentrate will be recycled to incorporate additional volatiles in the glass. EMF condensate must be processed through the Hanford Site ETF.

Technetium management is necessary to facilitate LSW disposal. Long-lived radionuclide technetium-99 is a fission product from nuclear reactors. Approximately 26,000 Ci of predominantly soluble technetium remains within the tank farms that will be processed as LAW. The primary chemical form of technetium-99 found in LAW is the pertechnetate anion (TcO_4^-), with a +7 oxidation state. Pertechnetate will not be removed from the aqueous waste during pretreatment. The compound will be immobilized in the LAW glass (though volatile at high temperatures), or in macro encapsulated SSW, all of which will be disposed of at the IDF. Due to a long half-life and high mobility, technetium-99 has the potential to be a major dose contributor at the IDF based on the PA. Sufficient risk to satisfying the performance standards may warrant a technetium management program.

The final disposition of spent LAW and HLW melters has not yet been determined (ORP-11242). The alternatives evaluated (DOE/EIS-0391, *Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington*) assume that the spent HLW melters will be packaged in an overpack and stored at the interim Hanford storage area until they can be removed for disposition and final disposal. For planning purposes, the final disposition of the LAW melters is assumed to be at the IDF to maintain consistency with the current performance measurement baseline.

The MW functional area includes the following focus areas:

1. Liquid Effluent Retention Facility (LERF) / ETF – The low radioactivity LSW output stream (evaporator overheads) will be transferred to the LERF for treatment at ETF. However, the ETF currently treats wastes from a number of sources on the Hanford Site. LSW feed streams will include the following:
    - Mixed Waste disposal trench leachates

- IDF leachates
- 242-A Evaporator condensates
- Laboratory wastewaters and other miscellaneous minor aqueous streams
- EMF overheads and other miscellaneous LSW

2. SSW – These wastes (i.e., radioactive solid wastes) are non-liquid waste debris and byproducts of Hanford Site operations.
3. LSW – As a result of WTP vitrification, a portion of the volatile species in the waste (e.g., fluorides, chlorides, some radionuclides [technetium]) will partition to the off-gas system and the concentrated condensate (via EMF) will become incorporated into the waste glass via recycle through the melters.
4. Technetium Management – The technetium management effort evaluates and guides the options for reducing the amount of secondary waste technetium-99 disposed at the IDF.
5. Cesium Management – The treatment of LAW must provide for the removal of cesium.
6. Melter Disposal – It is assumed that spent HLW melters will be packaged in an overpack and stored at the interim Hanford storage area until they can be removed for disposition and final disposal. For planning purposes, the final disposition of the LAW melters is assumed to be at the IDF to maintain consistency with the current performance measurement baseline.

This section includes the catalog sheets for the near-term technologies that fall under the MW functional area.

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HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

Investigate potential solutions to mitigate ammonia vapor release from Liquid Secondary Waste.

Ammonia Vapor Mitigation

TEDS ID: MW-02 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Solidification of Effluent Treatment Facility (ETF) liquid secondary waste is being pursued in conjunction with the planning for Direct-Feed Low-Activity Waste (DFLAW). Prior testing with simulants identified that ammonia vapor release during grouting is substantial for streams with high dissolved ammonia content. The Notice of Construction permit for the prior ETF solidification project had an allowable ammonia release of 2 lbs/hr. Mass balance projections indicate that actual releases could greatly exceed this level. Work in FY18 through FY21 has developed and demonstrated up to the engineering scale, a solidification process that binds soluble ammonia as the mineral struvite prior to solidifying the liquid waste. FY21 work also demonstrated the ability to grout the rinse water solution generated from cleaning an ETF grout facility mixer. Experiments to demonstrate the ability of the grout to solidify a range of expected brine feed compositions were met with process repeatability challenges by a different laboratory. Additional work is needed to address processing and storage issues that arise during the design, construction, and start-up of a full-scale grout facility.

TECHNOLOGY SOLUTION

Work was completed in FY21 at laboratory and engineering scales with simulant waste and simulant mixer rinse water. Tests showed reasonable set times, high compressive strength, and low ammonia flow rate during and after curing for up to 6 days. Experiments are planned for FY22 to support facility design, construction, and start-up. Tasks include resolving issues with process repeatability by different laboratories and personnel and evaluating the effects of thermal cycling and EDTA addition to the ETF brine.

Laboratory Set Up

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

Yes

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Ammonia Vapor Mitigation

TEDS ID: MW-02 Continued

ADDITIONAL TECH INFO

Grout Samples Curing

Engineering Scale Demo

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $500K

-Complete Formulation Development for Process Wastewater

- Develop Process Procedures

- Start-up Support

FY23: $450K

- Start-up Support

THREATS AND OPPORTUNITIES

DFLAW-0232-T: Secondary Liquid Waste Management LTA

MEASURABLE ORGANIZATIONAL VALUE

Successful testing will satisfy commitments made in the settlement agreement to complete the tech- nology demonstration.

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5.5 Dispose Tank Waste

Disposal is the ultimate goal for Hanford Site tank waste. The method of treatment, final waste form characteristics, and type of waste form will determine how and where the waste can be disposed. LSW effluents will be treated at the ETF and disposed at a permitted land disposal site. ETF SSW will be disposed of at the IDF. ILAW and potentially supplemental LAW will likely be disposed of at the IDF, with some offsite options being explored. Immobilized HLW (IHLW) will be interim-stored onsite and ultimately disposed of at an as-yet undetermined geologic repository. CH-TRU waste is planned to be disposed of at the Waste Isolation Pilot Plant (WIPP). There are other relatively benign wastes (e.g., submerged bed scrubber condensates) that may be treated offsite and disposed of at commercial waste disposal facilities.

The DTW functional area includes the following focus areas to assess potential methods of disposal for the waste:

1. IDF – The IDF is located on the Hanford Site in the 200 East Area and is the designated disposal location for ILAW. The facility consists of a single landfill with two expandable cells for extra capacity. The cells use a double lined system with leachate collection, detection, and removal capability.
2. IHLW Interim Storage – The path forward for IHLW interim storage entails sequential construction of potentially several modular facilities. One or more facilities will be provided as necessary to furnish IHLW interim storage capacity.
3. WIPP – The WIPP is the nation's underground disposal facility for DOE TRU solid waste. Hanford Site ships legacy TRU waste to WIPP as part of the Central Plateau Cleanup Company program to disposition solid waste landfills.
4. Offsite Disposition – Offsite disposition refers to both offsite treatment and disposal of Hanford tank liquid and/or related solid waste.
5. Offsite Transportation – Offsite transportation refers to future transportation systems needed for shipping Hanford waste (liquid and/or solid) to offsite treatment and/or disposal facilities. This effort supports offsite disposition by developing shipping transportation systems for material transport.

This section includes the catalog sheets for the near-term technologies that fall under the DTW functional area.

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Low Temperature Waste Form Process

HANFORD SITE
US DEPT OF ENERGY

TEDS ID: DTW-02 **Timetable: > 5 Years**

NEAR TERM

Develop and qualify a low-temperature waste form for supplemental immobilization of Hanford LAW. A low temperature immobilization process for Hanford LAW would be significantly less complex to design, construct and operate than a high-temperature vitrification process. Estimates indicate capital costs will be approximately seven times lower and operating costs three times lower for a low temperature process. A further benefit could be realized if a single grout facility is used to immobilize both LAW and Secondary Wastes.

TECHNOLOGY NEED

The Waste Treatment and Immobilization Plant (WTP) Project is designing and building a vitrification facility for immobilizing Hanford Site low-activity waste (LAW) in a glass waste form. However, the LAW Vitrification Facility has limited capacity and will only be able to treat about one-third of the total LAW within the mission duration timeframe (bounded for high-level waste [HLW] treatment). Additional LAW immobilization capacity is needed for timely completion of the waste treatment mission and to avoid protracted interruptions of the HLW Vitrification Facility operations. Low temperature supplemental LAW treatment (i.e., grout) could provide the needed capacity. However, waste form performance data for grouted LAW are needed for both a supplement analysis to the Tank Closure and Waste Management Environmental Impact Statement to construct and operate the facility and process, and for the Integrated Disposal Facility Performance Assessment, to allow ultimate disposal of the waste form. Technology maturation activities are also needed to support a future U.S. Department of Energy (DOE) Record of Decision on what process to use for supplemental immobilization of Hanford LAW.

TECHNOLOGY SOLUTION

The development approach is described in a Technology Maturation Plan that is patterned after the DOE/EM 413.1-4 technology maturation process and embodies a phased approach to mature the technology over multiple fiscal years. The logical progression of the technology development work includes formulation development, testing to support long-term performance projections for the performance assessment, engineering-scale integrated testing, and waste form qualification testing. Work to integrate a low temperature solidification process into the full WTP mission is also planned. This includes the development of sampling and analysis methods necessary to ensure RCRA LDR compliance in the final waste form.

Test Cylinders

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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Low Temperature Waste Form Process

TEDS ID: DTW-02 Continued

ADDITIONAL TECH INFO

Testing with Actual Waste

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22 - $1,569K
- Formulation Development
- Capture and Hold Method Improvements
- LDR Organic Sample and Send Method Development
- Long Term Performance - PA Support

FY23: $1,456K
- Complete Capture and Hold Method Improvement
- Complete LDR Organic Sample and Method Development
- Bulk Waste Form Improvement
- Actual Waste Testing

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less than Adequate

MEASURABLE ORGANIZATIONAL VALUE

The total savings from constructing and using a grout facility rather than a vitrification facility are estimated to be about $31 billion (un-escalated) and $95 billion (escalated). Using a grout facility in lieu of a vitrification facility would also save about 11 years' time treating all tank waste and about 13 years' time completing all SST retrievals.

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Immobilized LAW Glass Testing for IDF PA Support

HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

Perform engineering and laboratory tests to characterize Immobilized Low Activity Waste (LAW) glass to support the Integrated Disposal Facility (IDF) Performance Assessment (PA) update and future maintenance.

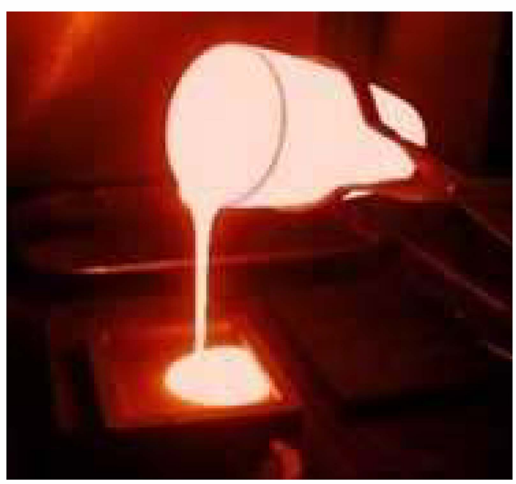
TEDS ID: DTW-03 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The Waste Treatment and Immobilization Plant (WTP) Project is designing and building a vitrification facility for immobilizing Hanford Site LAW in a glass waste form. Immobilized waste from the LAW vitrification facility, starting with direct-feed LAW processing, will be disposed of onsite in the Integrated Disposal Facility (IDF). Waste form performance data is needed to support the IDF Performance Assessment (PA) and PA maintenance to permit and operate the IDF. Work performed in FY 2017 through FY 2021 supported improvements in waste loading/processing. Additional work is needed to prepare the data packages used to update the IDF PA modeling platforms. Additional work is also necessary to verify long-term glass dissolution rates for enhanced glasses. The near-term risk associated with not performing this work is the necessity to restrict WTP operations to lower waste loading baseline glasses rather than expanding operations to include enhanced glasses. Long-term risks include the potential for higher operating costs for LAW immobilization and IDF disposal caused by the need for lower throughput to maintain lower waste loading in the glass and the subsequent generation of a greater volume of waste for disposal.

TECHNOLOGY SOLUTION

The 2017 IDF PA performed analysis using baseline glasses. However, recent work is being completed to develop new LAW glasses that can achieve higher waste loadings. The hope is to integrate the new glass formulations into DFLAW as soon as practical after DFLAW System hot commissioning. To implement enhanced glass formulation, testing data on the short- and long-term dissolution rate of the new glasses is needed. This information will be needed to support PA analysis of the fate of the enhanced glasses in the IDF and their potential impact on the environment. It is likely the PA analysis will be performed right before startup of DFLAW.



ILAW Glass Sample Formulation

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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Immobilized LAW Glass Testing for IDF PA Support

TEDS ID: DTW-03 Continued

ADDITIONAL TECH INFO

Ground Glass Samples used in Dissolution Rate Tests

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $2,475K
- Define Secondary Mineral Phases Reaction Network
- Prepare Data Packages for the IDF PA
- Monitor Long-Term Dissolution Test
- On-going IDF PA Maintenance Support

FY23: $2,630K
- Prepare Data Packages for the IDF PA
- Monitor Long-Term Dissolution Tests
- On-going IDF PA Maintenance Support

THREATS AND OPPORTUNITIES

DFLAW-0249-T: WIR Evaluation Approval is Delayed

DFLAW-0149-T: IDF Permits to Operate Including Disposal Authorization Statement (DAS) Delayed

MEASURABLE ORGANIZATIONAL VALUE

Production of enhanced glass as opposed to baseline glass will reduce total mission glass canister count by up to 50K, provide a potential savings of up to $1.86 Billion, and aid in keeping the mission completion target of 2065.

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HANFORD SITE
US DEPT OF ENERGY

Solidification and Stabilization of Solid Secondary Waste

TEDS ID: DTW-07 **Timetable: ≤ 5 Years**

NEAR TERM

Development and maturation of a technology for the solidification and stabilization of solid secondary waste (SSW) by macro or micro-encapsulation in grout waste forms.

TECHNOLOGY NEED

During DFLAW operations, radioactive SSW will be generated at the waste processing facilities. Such wastes are expected to include used process equipment, contaminated tools and instruments, decontamination wastes, high-efficiency particulate air filters, carbon absorption beds, iodine sorbent beds, and spent ion exchange resins. SSW treatment processes and waste forms will be needed in time to support DFLAW operations. Accordingly, these waste forms have been included and analyzed as part of the 2017 IDF PA. In FY16, information available from published literature was reviewed, surveyed and compiled in a data package for the 2017 IDF PA. Development and testing activities to collect data on Hanford SSW was started in FY17. Results in FY20 for ultra high performance grout (UHPG) indicate orders-of-magnitude improvement for contaminant retention over baseline formulations. Additional data using specific SSW materials is needed to confirm these results and provide data for upcoming PA maintenance activities. These results will also provide insight on the ability of UHPG to be used as a diffusion barrier for other waste forms.

TECHNOLOGY SOLUTION

Work scope priorities are based on the results of the 2017 IDF PA analysis, which indicated that there are 4 major SSW that have significant inventories of contaminants of concern for the IDF. Those 4 major SSWs, are sRF resin, HEPA filters, carbon bed adsorbers, and silver mordenite. Since then, a fifth SSW, A-532E resin, has been identified for iodine removal from ETF feed. This work will employ a variety of standard laboratory-scale tests to measure physical and chemical properties of grout/waste form formulations. The findings will then be assessed with anticipated IDF disposal requirements to identify waste forms and processing methods for producing SSW disposal packages. These results will also provide insight on the ability of UHPG to be used as a diffusion barrier for other waste forms. Work will be accomplished in four phases: 1) Formulation development; 2) Waste form fabrication and Qualification/Characterization; 3) Waste Form Performance Testing; and 4) Scale-up or Engineering Scale Testing.

Grout Flow Testing of Encapsulation Grout

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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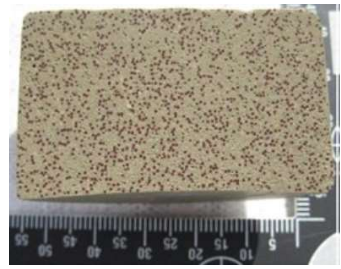
Solidification and Stabilization of Solid Secondary Waste

TEDS ID: DTW-07 Continued

ADDITIONAL TECH INFO

Samples During Formulation Development



sRF Resin in Grout

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $900K
- Waste Form Durability
- Leach Test of UHPG

FY23: $1,500K
- Leach Test of UHPG
- Development and testing of waste Form 5 (A-532E Resin)
- Waste Form Durability
- Development and testing of Waste Form 4 (Carbon Bed Adsorber)
- Waste Form Testing for scale-up

FY24: $1,800K
- Waste Form Durability
- Development and testing of Waste Form 4 (Carbon Bed Adsorber)
- Waste Form Testing for scale-up
- Testing with Real Waste

THREATS AND OPPORTUNITIES

DFLAW-0206-T: Secondary Sold Waste Management LTA (Tank Farms and WTP)

MEASURABLE ORGANIZATIONAL VALUE

Verify that SSW generated during DFLAW operations will meet DOE 435.1 requirements for disposal in the IDF. UHPCC has the potential for reducing the impact to groundwater in the IDF PA.

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IDF Long-Term Waste Form Durability Study (Lysimeter Data)

HANFORD SITE
US DEPT OF ENERGY

TEDS ID: DTW-08 **Timetable: ≤ 5 Years**

NEAR TERM

Validation of Performance Assessment (PA) (RPP-RPT-59958) models using field results from monitored and well understood/documented lysimeter tests are needed to improve stakeholder confidence in disposal facility and waste form performance. Increased understanding of model performance can allow modelers to better understand how well the model predicts Integrated Disposal Facility (IDF) conditions and could allow a reduction in conservatism in release estimates, resulting in better utilization of the IDF and lower IDF closure requirements and costs.

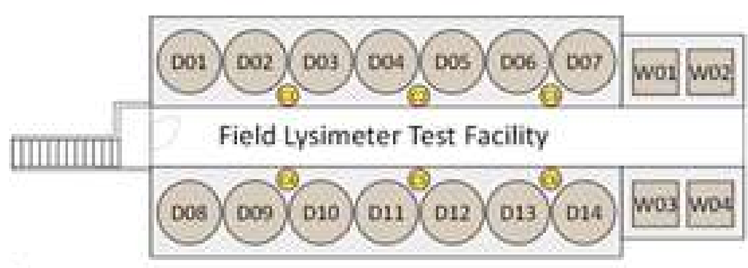
TECHNOLOGY NEED

A long-term study of LAW waste form degradation using the Field Lysimeter Test Facility (FLTF) on the Hanford Site will: 1) provide field experimental data on degradation of various waste forms; 2) be used to refine process model descriptions of contaminant (source term) release from the waste forms; 3) reduce uncertainties about the representativeness of laboratory testing results for determining long-term waste form performance under field conditions; 4) improve confidence in the IDF PA by providing data that verify parameters and assumptions used in the PA modeling, 5) determine potentially important impacts from co-disposal of the glass and cementitious waste forms; 6) determine changes in the physical (e.g., structural properties) and chemical (e.g., secondary phase formation, reducing capacity, leach rate) properties of the glass and cementitious waste forms during interaction with surrounding materials to improve long-term predictions of waste form performance; and 7) identify relevant secondary phases that are formed during waste form alteration in the lysimeter to improve long-term predictions of waste form performance.

TECHNOLOGY SOLUTION

Develop a test plan covering waste forms, surface to volume ratios, precipitation, and other parameters which influence waste form durability and are key inputs to performance assessment models such as STOMP and GoldSim. Focus will be on cementitious waste forms but glass will be included. Laboratory and field work will include:

1) Loading the lysimeters and monitor parameters needed as input and to validate models
2) Systematically retrieving samples, analyze them, and compare results to models ran to simulate sample/lysimeter history; including analysis for secondary phases.



Schematic of the Facility

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Submitted As Grand Challenge?

No

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IDF Long-Term Waste Form Durability Study (Lysimeter Data)

TEDS ID: DTW-08 Continued

ADDITIONAL TECH INFO

Aerial view of Lysimeter Location

PRELIMINARY COST ESTIMATE AND SCOPE SUMMARY

FY22: $990K

- Ongoing Monitoring

FY23: $1,947K

- Ongoing Monitoring
- Loading Additional Cells

THREATS AND OPPORTUNITIES

DFLAW-0206-T: Secondary Solid Waste Management LTA (Tank Farms and WTP)

MEASURABLE ORGANIZATIONAL VALUE

Facilitates DFLAW operations by reducing uncertainty associated with the IDF PA fate-and-transport modeling predictions for grout waste forms, specifically. Provides long-term data on containment release, at actual IDF conditions, that can be used to validate the numerical models. Reduces conservatism used for the IDF PA analyses.

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5.6 Technology Development Funding

WRPS collaborates with the DOE National Laboratory network, academia, and industry experts to develop innovative approaches to enhance our ability to meet the mission needs. This section details technology development funding.

WRPS prioritizes technology development tasks annually. Tasks that are selected for funding seek to increase safety, improve efficiency, and minimize life cycle costs associated with completing the TOC mission. This section details the following:

- Technology development program funding
- National Laboratory support to funded programs
- National Laboratory, academia, and supplier/contractor support distribution

Development activities with their budgets for FY2022 are shown in Figure 5-1. The figure shows the total funding along with individual program funding levels expressed in dollars and depicted in a pie chart as percentages. During FY 2022, technology development funding will be invested in the Non-Destructive Examination (14%), ILAW Glass Testing (14%), and Radioactive Waste Test Platform (11%) projects, among other projects.

Efforts are made to evaluate all work scope and utilize the appropriate laboratory to support the project based on the laboratory capabilities and past experience. For FY 2022, National Laboratory support is being provided by Pacific Northwest National Laboratory (PNNL) and Savannah River National Laboratory (SRNL). Investments in technology were also made with the academic institution Vitreous State Laboratory (VSL). Development activities in FY 2021, supported by the National Laboratories are shown in Figure 5-2. National Laboratories expertise was and will be utilized in these development programs. National Laboratory support funding distribution for these technology development programs is shown in Figure 5-2. The figure shows the total funding and individual program funding levels expressed in dollars and depicted in a sunburst chart. For FY 21 the majority of the funding (75%) went to PNNL.

In addition to National Laboratory and academia institution support, WRPS also teams with commercial suppliers/contractors, such as Atkins. However, PNNL received 55.5% of the support as the dominant supplier. A complete list of teaming suppliers is shown in Figure 5-3. The figure shows the funding percentage distribution.

Technology development funding is provided primarily by the CTO. When available, some funding may be provided by other tank farm organizations such as Tank & Pipe Integrity, Project Office, and Closure & Interim Measures. Funding provided by other tank farm organizations is distributed similarly to CTO distributed funds, however it is not included herein.

Figure 5-1. CTO-Managed Technology Development and Maturation Scope, Budget for FY22

CTO Program Management		
CTO Program Management	$	4708.502
Total	$	4,708.5
DFLAW Maturation		
Radioactive Waste Test Platform	$	2376.77
ILAW Glass Testing	$	2870.332
Lysimeter	$	1092.557
Secondary Waste Form Dev	$	838.173
SLAW Treatment Alternatives	$	1729.95
Flowsheet GAPs	$	857.064
Solid Secondary Waste Mgmt	$	521.112
Total	$	10,286.0
Vapors		
DFAS (SmartSites)	$	135.906
Total	$	135.9
Operational Support		
Non-Destructive Examination	$	2988.843
Tank Repair	$	1294.783
Hanford Waste End Effector	$	317.627
Off-Riser Sampler System	$	144.213
Machine Learning	$	280.694
Total	$	5,026.2
Retrievals		
Sludge Retrieval	$	835.888
Total	$	835.9

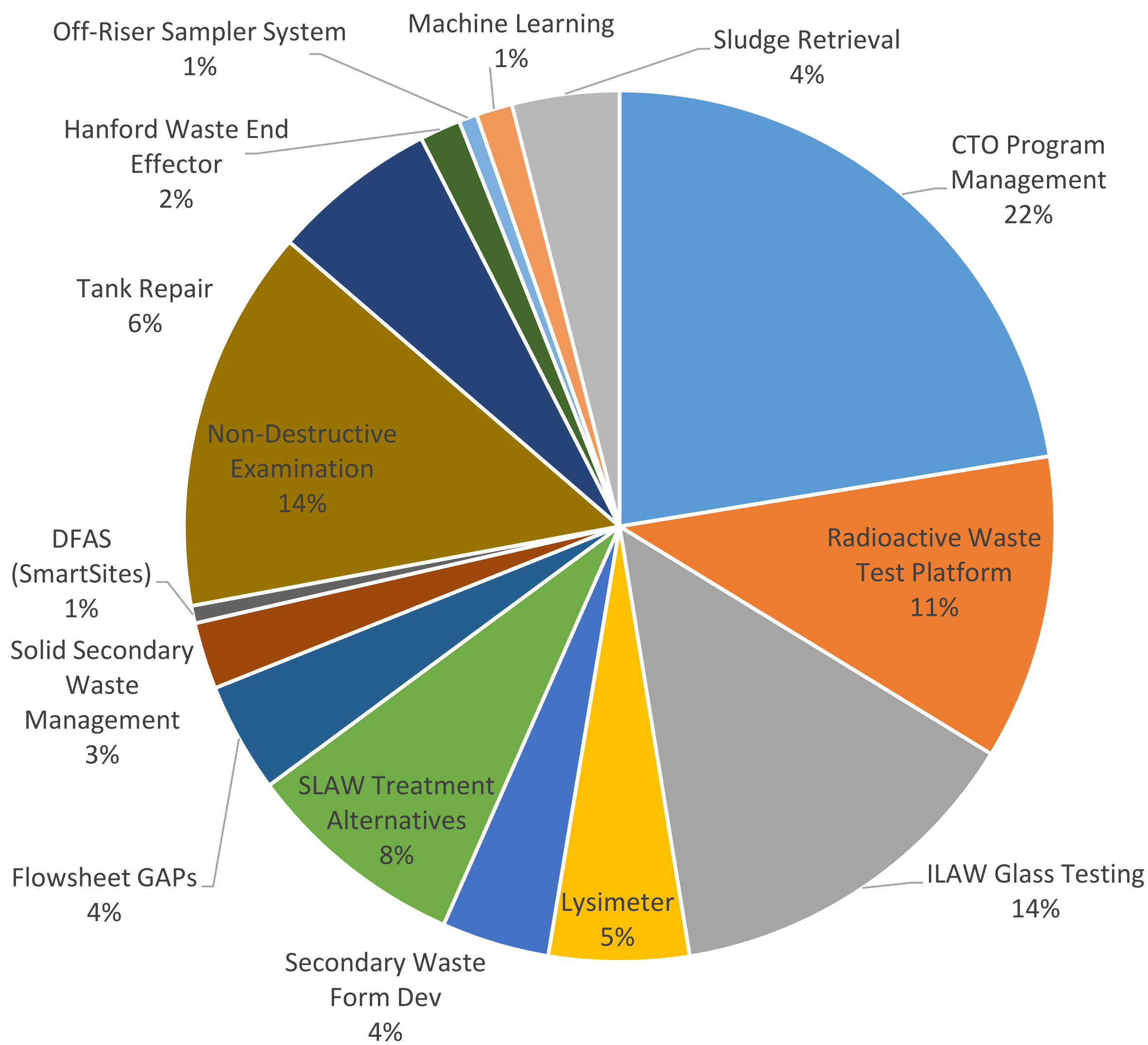


Figure 5-2. National Laboratory Support, Actual from FY21

National Laboratory Support ($K)		
PNNL		
DFLAW Maturation	$	6,463
Vapors Mgmt	$	224
LAWPS/TSCR	$	393.8
Operational Support	$	2,562
Total	$	9,644
SRNL		
DFLAW Maturation	$	574
LAWPS/TSCR	$	83
CTO Program Mgmt.	$	372
Total	$	1,029
VSL		
DFLAW Maturation	$	2,254
Total	$	2,254

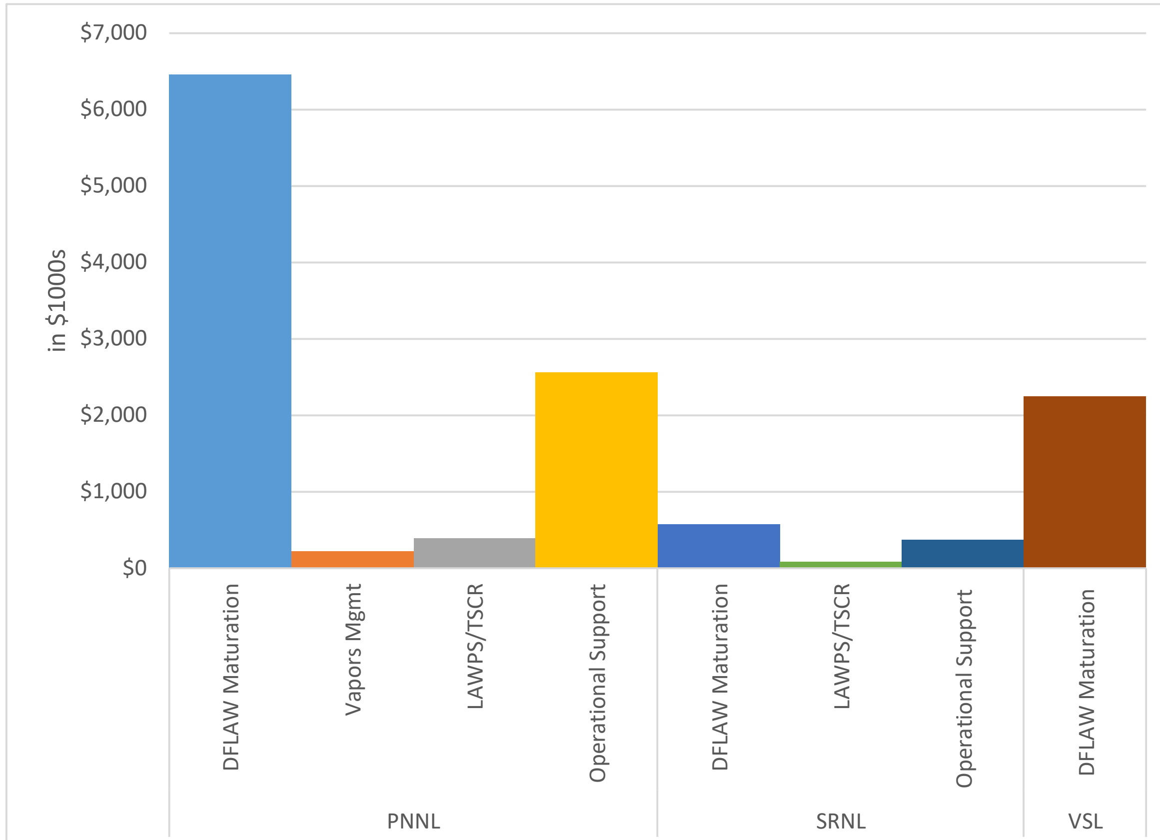
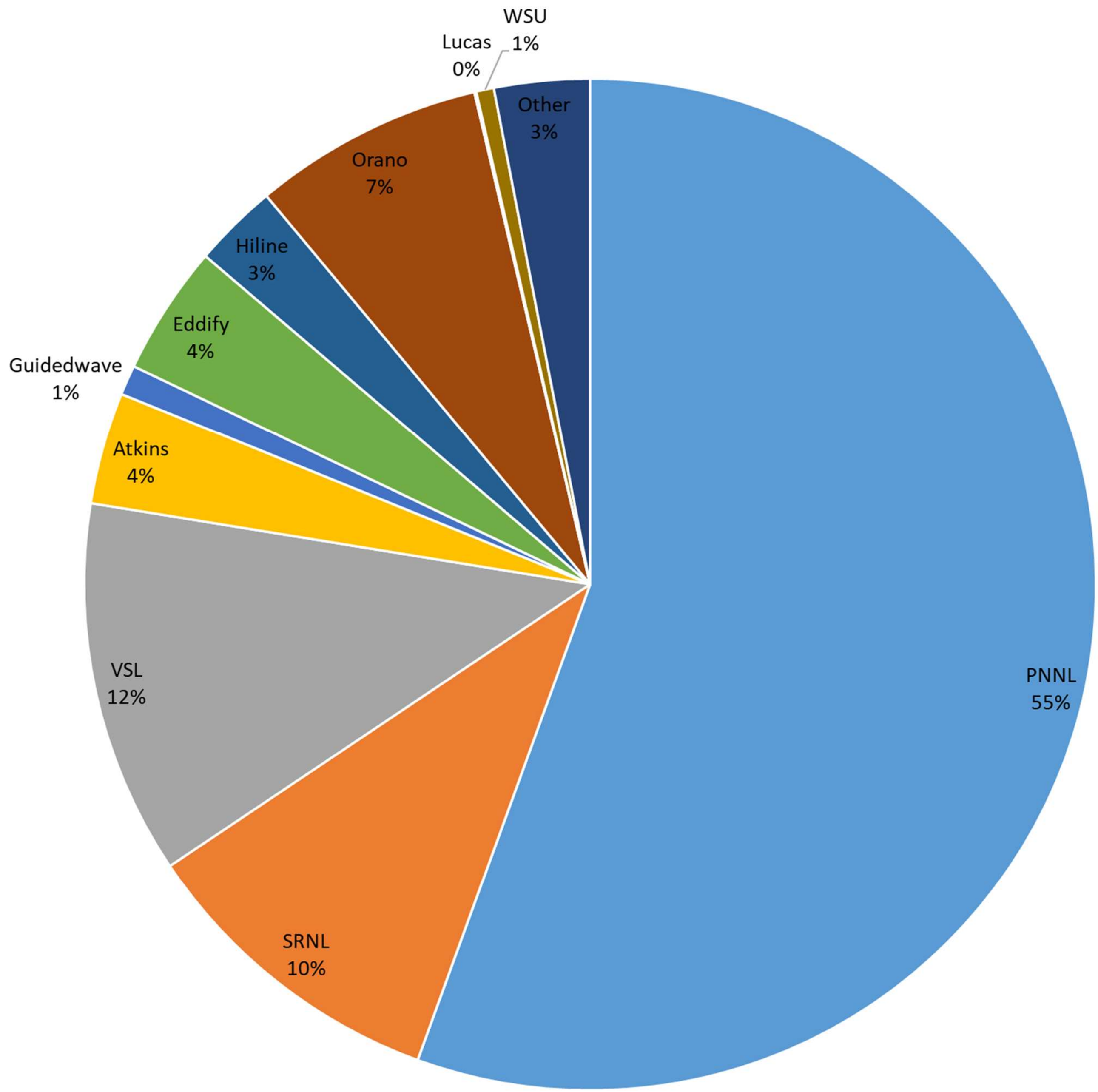


Figure 5-3. Technology Development Funding Distribution, Actual from FY22

TD Funding Distribution		
National Laboratory Support		
PNNL	55.5	%
SRNL	10.1	%
Academia		
VSL	12.0	%
WSU	0.6	%
Suppliers		
Atkins	3.6	%
Guidedwave	1.0	%
Eddify	4.1	%
Hiline	2.7	%
Orano	7.4	%
Lucas	0.1	%
Other	3.1	%



6.0 FUTURE TECHNOLOGY NEED DESCRIPTIONS

This section lists those proposed technology needs that are not currently targeted as near-term needs. This means the technology need is still recognized as a need; however, it is not currently being pursued for development. A technology need may be unpursued for a variety of reasons, the most common reasons being the technology is not needed in the next 5 years. These technology needs are listed in table format for each of the five basic functional areas. Catalog sheets for these technology needs are one page each and can be found in APPENDIX C.

Technology needs that have been overcome by events, developed and implemented, or otherwise deemed no longer in need of development, are considered Retired. A list of Retired TEDS along with retirement criteria can be found in APPENDIX E.

6.1 Manage Tank Waste

Table 6-1 lists technologies related to MTW that are not currently being pursued. Catalog sheets for each technology can be found in APPENDIX C.

Table 6-1. Future MTW Technologies

TEDS #	Title
MTW-10	Improved Inspection Methods for DST Primary Tank Walls
MTW-13	Improve Liquid Observation Well Data Acquisition
MTW-40	Improve Sampling Methods of Head Space
MTW-50	Additional Tank Space
MTW-57	Predicting Behavior of Mercury in EMF
MTW-59	Nitrosamine Monitoring and Reduction
MTW-70	Plutonium Particulate Criticality Safety Issue Resolution
MTW-71	Improve Best-Basis Inventory with TWINS Database
MTW-72	Continuous Air Monitor Remote Observation
MTW-74	Measure Liquid Loss from Evaporation
MTW-75	Reduce or Eliminate Equipment Contamination
MTW-76	Online Monitoring
MTW-78	In-Tank Volumetric Nondestructive Examination
MTW-80	Automated Visual Recognition Wireless Remote Video Monitoring
MTW-81	Radiation Tolerance Multi-Use Manipulator System
MTW-83	Secondary Liner Bottom Damage Mitigation Technologies
MTW-84	Pipeline Forensic Inspection Technology
MTW-85	Remote for Surface Examination
MTW-86	Protective Measures for Waste Transfer System Lines
MTW-88	Liquid Air Interface Sampler
MTW-89	Remote Concrete Surface Cleaning Apparatus
MTW-90	Water/Waste Volume Measurement for 242-A C-A-1 Vessel
MTW-91	Tank-Side Waste Evaporation
MTW-93	Cs Online Monitoring for TSCR
MTW-96	Enhanced Worker Capabilities
MTW-97	Continued Need for Improving Tools for Tank Farm Projects
MTW-98	Long-Reach Robotic Tool for Waste Storage Tank Pits
MTW-99	Tank Farm Smart Operating Procedures
MTW-100	Increased NDE Volumetric Inspection

6.2 Retrieve Tank Waste

Table 6-2 lists technologies related to RTW that are not currently being pursued. Catalog sheets for each technology can be found in APPENDIX C.

Table 6-2. Future RTW Technologies

TEDS #	Title
RTW-03	Remote Tank Farm Above Ground Inspections
RTW-04	Near Tank Soil Sampling
RTW-07	Post Waste Retrieval Updates to WMA CPA and Long-Term Maintenance
RTW-08	Dry Retrieval Systems
RTW-15	Evaluate Back-Up Options for HLW Delivery from the Tank Farms
RTW-16	Develop Integrated HLW Feed Qualification Plan
RTW-17	Assess Deep Sludge Pump Reliability for DST Mixer & Transfer Pumps
RTW-18	Improved Heat Removal for AW & AN Tanks TSR Heat Limits
RTW-19	Removal of SR-90 and TRU
RTW-21	Improve ESP – A Thermodynamic Modeling Program
RTW-23	Waste Transfer Pipe Unplugging
RTW-25	Void Filling to Prevent Collapse
RTW-27	Improved Solubility Modeling
RTW-31	In-Tank Sampling Technologies for Plutonium Particles
RTW-32	Criticality Safety Control Strategy for Particulate Plutonium
RTW-34	Remove Residual Solids in Non-Leaking Tanks
RTW-39	Risk-Informed Tank Retrieval Modeling Optimization
RTW-43	Computer Simulator to Measure Retrieval Operator Skills
RTW-44	Quantification of Solids in DSTs
RTW-52	Barrier Technology
RTW-53	Improved Configuration Documentation
RTW-54	Modular Tank Waste Treatment
RTW-56	Technology to Support Risk-Based Retrieval & Closure
RTW-57	Plutonium/Absorber Mass Ratios Measurement
RTW-58	Tank Crust Sampler
RTW-59	Retrieval of Sludge from Miscellaneous Underground Storage Tanks

6.3 Process Tank Waste

Table 6-3 lists technologies related to PTW that are not currently being pursued. Catalog sheets for each technology can be found in APPENDIX C.

Table 6-3. Future PTW Technologies

TEDS #	Title
PTW-26	High- to Mid- Fidelity Consolidated Operations Training Simulator
PTW-40	Simplified DFHLW Flowsheet
PTW-42	High-Level Waste Direct Vitrification – Condensate Treatment
PTW-45	Operations Productivity & Analysis Tools
PTW-46	Advance CH-TRU Tank Waste Treatment Technologies
PTW-48	Prevention of Hydrogen Gas Buildup
PTW-49	Feasibility of Removing Nitrates from the LAW Feed
PTW-50	High-Level Waste Solids Segregation
PTW-51	Nitrite-Hydroxide Solubility to Determine Aluminum Solubility in DFLAW
PTW-54	Real-Time Process Control for DFLAW
PTW-56	Treated Waste Concentration/Evaporation
PTW-57	In-Tank Solids Suspension
PTW-58	Solids Settling Rate Determination/Solids Washing Techniques

6.4 Manage Waste

Table 6-4 lists technologies related to MW that are not currently being pursued. Catalog sheets for each technology can be found in APPENDIX C.

Table 6-4. Future MW Technologies

TEDS #	Title
MW-10	Remotely Operated or Automated ETF Internal Tank Cleaning Device
MW-12	Upgraded Solid Waste Information & Tracking System
MW-13	Transportation Requirements for New Equipment Disposal
MW-15	At-tank Technetium and Iodine Removal & Disposition

6.5 Dispose Tank Waste

Table 6-5 lists technologies related to DTW that are not currently being pursued. Catalog sheets for each technology can be found in APPENDIX C.

Table 6-5. Future DTW Technologies

TEDS #	Title
DTW-06	Advance Liquid Waste Transportation Capability
DTW-10	Evaluation of Commercial Treatment and Offsite Disposal
DTW-11	Integrated Disposal Facility Risk Budget Tool Monitoring
DTW-12	Evaluation of Natural Analogues to Support Tailored Grouts
DTW-13	Long-Term Durability of Cementitious Waste Forms
DTW-14	Complex-Wide Database for Cementitious Waste Form Properties

7.0 INNOVATIONS

In addition to the technology development activities, WRPS regularly supports the Hanford operations by producing many unique tool designs designated here as Innovations. These Innovations are projects undertaken by various project engineering groups that do not require prolonged development activities. Many of the Innovations are commercially available items that are modified in some way for use in the unique Hanford environment. Innovations range from modified manual extended reach tools to more advanced robotic systems. Table 7-1 is a list of innovative projects undertaken by WRPS in FY21.

Table 7-1. Innovations

Name	Description
Core Catcher	Collects core drilling waste and prevents workers from needing to enter highly contaminated 242-A Evaporator Pump Room
Core Drill Guide Assembly	Allows accurate placement of the core drill and associated concrete anchors while maximizing worker safety
Core Drill Wall Clamp	Alleviates legacy problems associated with spalling during pit wall coring and subsequent pit repair
Hydraulic Pipe Bender	Allows safe bending of jumpers for disposal while preventing size reduction via higher risk cutting methods
Integrated Pressure Washer System	Complete, high=pressure water delivery system for decontamination of Long-Length Equipment
Long-Length Internal Pipe Grinder	Rapidly-executed tool for removing internal pipe interferences for Evaporator Feed Pump installation
Mini Conveyor System for Excavation	Increase worker safety during excavation with a simultaneous significant increase in productivity
Modula Extended-Reach Hacksaw	Adaptable solution for remote material cutting without pit entry
Nozzle Mounting Plate Assembly	Allows precise placement of the new wall nozzle assembly on the first attempt
Pipe Cap Sizing and Installation Tools	Simple, reliable tools for measuring and installing pipe caps without pit entry
Pump Room Core Drilling and Wall Nozzle Installation	Tool suite which prevents workers from needing to enter highly contaminated 242-A Evaporator Pump Room
RD8200 Cable Locator Implementation	Reliable approach to identification of energized electrical obstructions
Solid Sampler Retrieval System & Enhancements	New solid sample retrieval system speeds up work evolution and reduces worker strain and dose
Solid Sampling Support Equipment	Low-cist, reliable remote handling and shielding equipment makes sampling extreme-dose waste possible

Summaries of these Innovations are included in APPENDIX G.

8.0 EMERGING ISSUES

As day to day operations continue, there is the potential for unexpected issues to arise. This section describes those emergent issues and the technology development activities planned to address them.

8.1 Transfer Line Corrosion

The Hanford Tank Farms employ Pipe-in-Pipe transfer lines to move waste between tanks and treatment facilities. A borescope inspection of the AW farm transfer line SN-265, standing water was found between the primary pipe and the secondary pipe. A second borescope inspection of the encasement was conducted and confirmed that the accumulation of the water was due to a localized low point and the likely source is condensation. There was also evidence of increased corrosion on the safety significant primary piping, which resulted in Operations requesting Engineering assess the condition.

The appropriate Operations and Engineering groups are conducting an extend of condition of SN-265 and similar pipe-in-pipe installations to determine root cause and fit for use status. Additionally, an effort was kicked off to develop a method of in-situ transferline monitoring. Existing vendors for similar applications were contacted and application requirements were discussed.

A demonstration of a permanent in-situ guidedwave UT monitoring system is being planned for late FY22. The results of the demonstration will be used to determine next steps. Development of a transfer line monitoring system could address the needs detailed in MTW-84 and MTW-86.

8.2 AY-101 Solids Mobilization

According to RPP-ASMT-6128, AY-101 has been identified as the DST most at risk of failure due to multiple factors, including chemical composition. The potential exists for increased corrosion at the tank bottom due to non-conforming interstitial liquid within the solids. Testing data from 2019 shows that the waste currently presents a low corrosion risk, however the twin to AY-101, AY-102, had a similar technical basis prior to being removed from service due to integrity issues with the primary tank bottom.

Multiple approaches are being evaluated to address potentially corrosive conditions inside AY-101 including mechanically preventing localized concentration of any one substance and possible chemical alterations to discourage material degradation. These approaches could address the need identified in RTW-17.

9.0 SUMMARY AND CONCLUSIONS

ORP is responsible for managing and completing the RPP mission, which is comprised of both the Hanford Site tank farms operations and the WTP. The RPP mission is to accomplish the following:

- Safeguard and safe management of over 54 Mgal of nuclear waste stored in Hanford tanks
- Retrieve and Treat the waste
- Achieve safe waste disposition to protect the Columbia River and the environment

To reduce the risk and cost associated with these objectives, new technologies are regularly implemented. The identification of these technologies comes from a variety of sources, collected and prioritized in this Roadmap.

9.1 Summary

The Roadmap catalogs ideas for evaluation for each of the TOC process or functional areas. These ideas capture specific issues and potential approaches involving the development of new technology or innovative application of existing technology to accelerate threat reduction and lower life cycle costs. This information is intended to support the FY planning and National Laboratory contracting processes to ensure that RPP mission technology needs are supported as necessary. In addition, the Roadmap provides a basis for strategic planning by identifying opportunities to use technology solutions to enhance mission efficiency.

9.2 Conclusions

A revision of this Roadmap occurs annually. The revision is developed in a systematic manner to facilitate sound strategic, programmatic, and fiscal planning regarding existing technology gaps in the RPP mission. Each year expert personnel are solicited for input from each of the five functional areas of the RPP flowsheet. Input is provided in standardized TEDS format to ensure consistent reporting.

Based on TEDS input, the technology needs may be tied to projects or require development. As the RPP mission consists of many interwoven, interdependent unit operations, a technology gap or need in an upstream unit operation can cause impacts throughout many functional areas. The Roadmap reconciles individual technology development activities and combine efforts where possible. This process has been enabled in large part due to efforts of National Laboratory testing and development to meet the growing needs of Hanford to safely dispose of the stored waste.

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APPENDIX A BACKGROUND INFORMATION

An estimated 56 Mgal[2] of chemical and radioactive wastes are stored in 158 underground storage tanks at the Hanford Site in southeastern Washington State. This waste is the result of plutonium production for the nation's nuclear defense program and ensuing waste management. There are 149 SSTs that were constructed between 1943 and 1964. There are 28 DSTs[3] that were constructed between 1968 and 1986. Table A-1 provides service life details of the DSTs. Tank 241-AY-102 was taken out of service in 2012 due to primary tank leaking. The total number of active DSTs is therefore 27.

Table A-1. DST Service Life

Tank Farm	Number of Active Tanks	Construction Period	Initial Operation	Design Life	Current Age as of 2022
AY	1	1968-1970	1971	40	51
AZ	2	1970-1974	1976	20	46
SY	3	1974-1976	1977	50	45
AW	6	1976-1979	1980	50	42
AN	7	1977-1980	1981	50	41
AP	8	1982-1986	1986	50	36
Total	27				

The SSTs contain a complex and diverse mix of radioactive and chemical waste in the form of sludge, salt cake, and supernate. The SSTs have had nearly all pumpable liquid removed as part of the Interim Stabilization Program also known as salt well pumping; approximately 3 Mgal remain across 149 tanks. The different waste forms necessitate a variety of unique waste retrieval, treatment, and disposition methods. Descriptions and volumes of these waste phases are provided in Figure A-1.

The Atomic Energy Commission built original DSTs to handle high-level waste from fuel reprocessing and waste management. The design has evolved as the Hanford mission changed. The RPP mission will require DST operation far beyond their design life. As such, maintaining the DSTs is a key mission goal. The waste in DSTs, though not as diverse as the SSTs, includes salt cake and sludge but primarily consists of supernate.

In 1989, the DOE, U.S. Environmental Protection Agency, and Washington State Department of Ecology (Ecology) entered into an enforceable compliance agreement with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989),[4] hereinafter referred to as the Tri-Party Agreement. The Tri-Party Agreement set forth milestones for tank waste retrievals and tank closures. DOE, the regulatory agencies, and the stakeholders all view tank waste cleanup as a top long-term priority. The tank waste must be retrieved, treated, immobilized, and permanently disposed of to conform to the Tri-Party Agreement provisions. The project tasked with managing this program is the RPP.

[2] Waste volumes fluctuate as a function of tank farms operations. The separate waste form volumes that total 54.1 Mgal (Figure 2-1) were derived from HNF-EP-0182, *Waste Tank Summary Report for Month Ending June 30th, 2020.*
[3] 27 of 28 are in service since tank AY-102 was taken out of service in 2012.
[4] This reference includes all applicable amendments of the Tri-Party Agreement.

Figure A-1. Hanford Tank Waste Description

Supernatant

Liquid above the solids or in large liquid pools in waste storage tanks.

Image taken from B-201 in-tank video (Video ID: 15714)

Saltcake

Soluble salts in waste storage tanks formed by the evaporation of liquid waste from nuclear reactor fuels reprocessing. Characterized by high porosity, interstitial liquid drainability, and crystalline texture.

Image taken from BY-111 in-tank video (Video ID: 13060)

Sludge

Insoluble hydrated metal oxides and fission products in waste storage tanks from nuclear reactor fuels reprocessing. Characterized by low porosity, reduced interstitial liquid drainability, and mud-like texture.

Image taken from T-104 in-tank video (Video ID: 17990)

The RPP mission (ORP-11242, *River Protection Project System Plan)* is to accomplish the following:

- Safeguard and safely manage the estimated 56 Mgal of waste stored in the Hanford Site tanks
- Treat the waste
- Ensure safe waste disposition to protect the Columbia River and the environment

The TOC is a part of the RPP. The responsibility of the TOC is to accomplish the goals of the first item by storing, maintaining, and retrieving tank waste. The future responsibilities of the TOC are to feed tank waste to the WTP to accomplish the second item and help monitor the waste forms that are disposed on the Hanford Site to accomplish the third item.

APPENDIX B ROADMAP EVOLUTION

The initial version (Revision 0) of this Technology and Innovation Roadmap (Roadmap) was released in May 2010 in response to the 2009 National Academy of Sciences report, and was in alignment with the philosophy of the then Assistant Secretary for EM of leveraging existing technology, using lessons-learned from across the complex, and incorporating "transformational technologies" to improve the mission. The scope for Revision 1 in 2015 was to identify technology gaps, prioritize technology needs, and advocate the use of National Laboratories to provide technical support, with an end goal of completing the River Protection Project (RPP) mission. The scope for Revision 2 in 2016 was the same; however, the content was updated to incorporate interim progress and changing mission priorities. The scope for Revision 3 in 2017 was the same as the other revisions; however, Revision 3 improvements included addressing integration of the DOE ORP GC technologies and updated technology prioritization and ranking processes based on ORP mission objectives.

Revision 4 in 2018 served to more closely link technologies with risks identified in the WRPS Risk Register. New technologies are likely required to meet the obligations of the TOC and overall RPP mission. This Roadmap served to further identify and determine the funded and non-funded waste remediation technologies in order to inform fiscal budget planning, prevent redundant efforts, guide National Laboratory research, and communicate with stakeholders. Revision 4 was intended to be a planning document; the conclusions of Revision 4 were based on technological priorities for fiscal year (FY) 2019. The TEDS sheets may identify cost from prior years, but this is merely for information purposes. Revision 4 required updates based upon ORP direction. The most direct way of creating the updates was through addendum RPP-PLAN-62988, *Addendum to the Technology and Innovation Roadmap Rev. 4*.

RPP-PLAN-62988 documents the results of an evaluation of a National Laboratory Support Plan for Direct-Feed Low-Activity Waste (DFLAW) Startup, Commissioning, and Operation (led by Savannah River National Laboratory and Pacific Northwest National Laboratory) against Revision 4 of the Roadmap and to expand the coverage it includes input from other Hanford Site contractors. To do this expansion, TOC WRPS reviewed National Laboratory capabilities identified to support an operating facility considering lessons learned from operating facilities across the DOE complex. In addition, WRPS contacted WTP and Plateau Remediation contractors to identify technology needs. The addendum contained two elements to supplement the Roadmap that expand the scope to include input from the National Laboratory matrix and other contractors.

Revision 5 of the Roadmap was a direct update to Revision 4 and includes information from RPP-PLAN-62988. Additional input was provided at two Savannah River Site workshops: Cementitious Materials Technology Exchange (2019) and DFLAW Glass Discussion Group (2019).

APPENDIX C BALANCE OF TECHNOLOGIES CATALOG SHEETS

C.1 Manage Tank Waste

The following are the one-page catalog sheets of the balance of the MTW TEDS.

CHIEF TECHNOLOGY OFFICE

washington river protection solutions

HANFORD SITE
US DEPT OF ENERGY

Advancement of the DST nondestructive examination program through development of a more versatile and capable inspection technology. Faster and more comprehensive inspection of the DST primary tank wall, including welds and heat affected zones, could be realized.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

Improved Inspection Methods for DST Primary Tank Walls

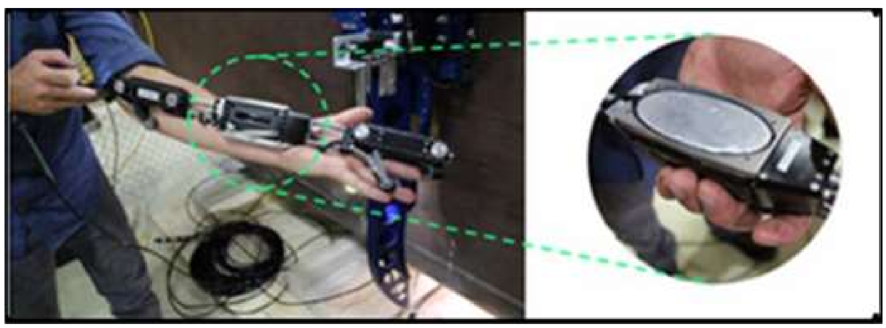
TEDS ID: MTW-10 **Timetable: > 5 Years**

TECHNOLOGY NEED

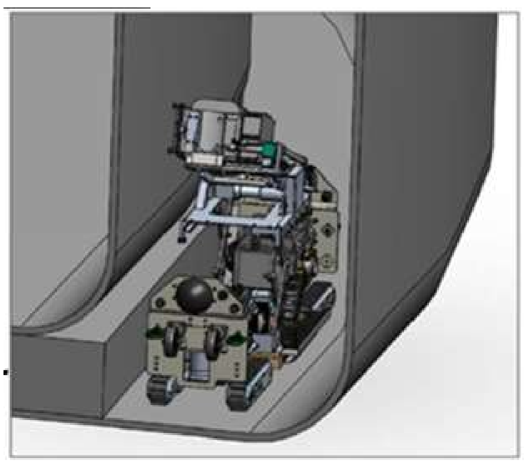
Limited corrosion data for welds and heat-affected zones was identified as a contributing deficiency. Advancement of the double-shell tank (DST) nondestructive examination program through development of a more versatile and capable inspection technology has been identified as a means to correct the deficiency. In doing so, faster and more comprehensive inspection of the DST primary tank wall, including welds and heat-affected zones, could be realized.

TECHNOLOGY SOLUTION

Both South West Research Institute and Guidedwave / Eddify systems have the greatest potential for increasing the examination of the side walls. Both systems are detection systems. Once a flaw is generally detected, normal beam UT can be used to determine approximate dimensions.



Guidedwave Phased Array



SWRI EMAT Concept

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Failure in West Area

TFIRR-0045-T: DST Failure in East Area

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US DEPT OF ENERGY

Increased NDE Volumetric Inspection

TEDS ID: MTW-100 **Timetable: > 5 Years**

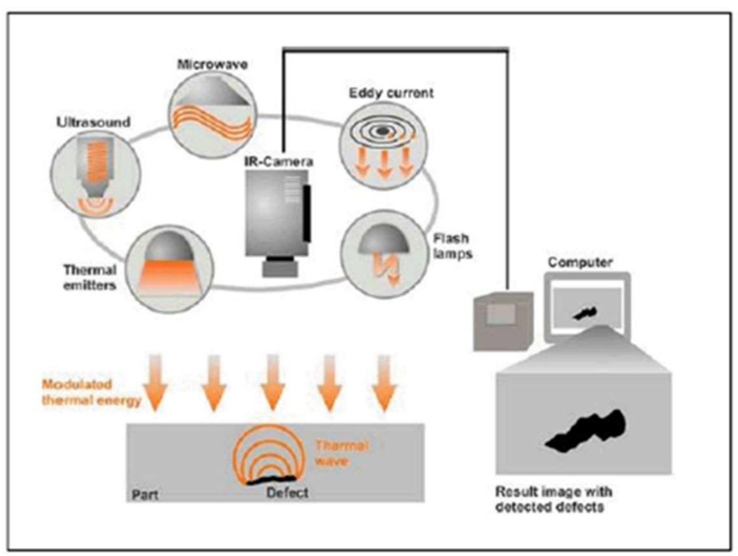
FT uses an illumination source that induces a temperature rise at the inspection surface, generally in the form of an impulse (high intensity pulse). Changes in material property can cause a change thermal indication which can be read by an infrared camera.

TECHNOLOGY NEED

There is a need to develop nondestructive examination (NDE) systems to increase the volumetric NDE of the aging Hanford tanks. Current systems only inspect about 2% of the double-shell tanks (DSTs). This amount was deemed acceptable when general corrosion was thought to be the primary means of degradation. Localized corrosion is now the mode degradation thought most prevalent. As such, the inspection regime needs to extended to a great extent of the tank.

TECHNOLOGY SOLUTION

Numerous technologies may be available for this need. They could include use of flash thermography (FT), guided UT waves, Electromagnetic Acoustic Transducers and others. A limited technology evaluation of FT was conducted, but was found in need of further development because of deployment issues. Should these issue be addressed the technology would provide an adequate solution. As such, FT along with other candidates should be explored to improve the understanding of DST integrity.



FT System Elements

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

TFIRR-0045-T: DST Failure in East Area

TFIRR-0046-T: DST Failure in West Area

TFIRR-0048-T: SST Failure in West Area

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Improve Liquid Observation Well Data Acquisition

TEDS ID: MTW-13 **Timetable: > 5 Years**

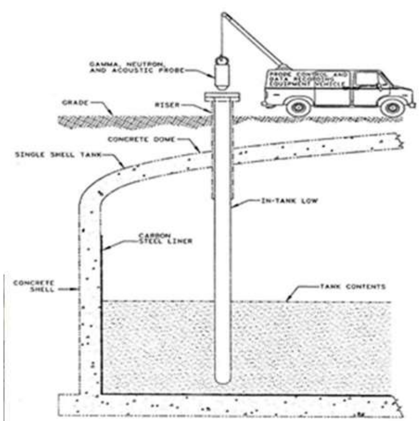
Measurements of tank interstitial liquid levels are time-intensive and do not occur frequently enough to develop useful level trends. Improved sensor technology and automation would allow for more frequent readings and less time for field crews in the tank farms.

TECHNOLOGY NEED

Liquid observation well (LOW) scans are currently obtained by a four- person crew in a specially outfitted van. The crew risks exposure to radiation from both the tank waste and the LOW probe source every time they conduct scans. An automated LOW system would reduce worker exposure. LOW readings are obtained approximately 4 times a year; this does not support the amount of trending data needed to detect intrusions or leaks in a timely manner. There has been no research conducted into improved sensor technology, which would allow for easier deployment of an automatic system for obtaining LOW scans. Research is necessary to determine the feasibility of improved technology and automated scanning. Once improved sensor technology has been identified, a system is planned to be designed, built, tested and deployed.

TECHNOLOGY SOLUTION

Research, design, build, test, and install an automated system to measure LOW neutron and gamma in selected single-shell tanks with a program to analyze and trend data coupled to the OSIsoft PI System



VAN MOUNTED LIQUID OBSERVATION WELL (LOW) SURVEILLANCE SYSTEM

THREATS AND OPPORTUNITIES

TFIRR-0047-T: SST Failure in East Area

TFIRR-0048-T: SST Failure in West Area

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

2 Years - 3 Years

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Improve Sampling Methods of Head Space

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US DEPT OF ENERGY

Improved methods and instrumentation are needed to measure particle size distributions of head space particulates. Improved instrumentation is also needed to capture, preserve and analyze head space particulates.

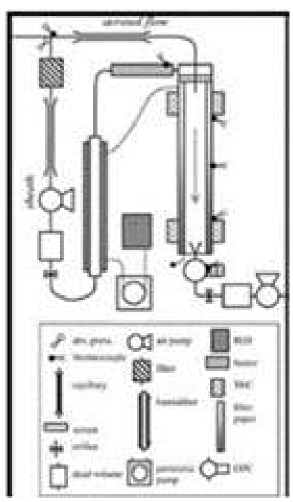
TEDS ID: MTW-40 **Timetable: > 5 Years**

TECHNOLOGY NEED

A program is needed to sample and measure head space particulates. Information gathered would help to mitigate exposure risks in the tank farms. Instrumentation is needed to capture, measure, and preserve aerosolized tank constituents for laboratory analyses. In addition, laminar-flow hood capabilities would be essential to laboratory analyses of particulates.

TECHNOLOGY SOLUTION

Head space sampling methods and instrumentation need to be improved to capture and preserve head space particulates. Deploying cloud condensation nuclei (CCN) technology to measure particle size distributions of head space particulates before and after waste-disturbing activities would enable better estimation of the magnitude of particulate generation during these activities. Impactor technology can be deployed to capture head space particulates. Impactors may also be coupled to CCN instrumentation for real time measurement of particle size distributions prior to particulate capture. This program would design and assemble measuring and sampling (CCN and impactor) technologies for improved understanding of particulate generation to help mitigate personnel exposure risks in the tank farms.



Flow Schematic

Cloud Condensation Nuclei Counter

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

WRPSC-0003-T: Tank Vapors Controls Impact Project Execution

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US DEPT OF ENERGY

Additional Tank Space

Development of a retrieval support system which can add capacity for use in continued SST waste retrieval missions and risk reductions of aging tanks. New tank capacity would be used to safely store, stage, transfer and potentially treat retrieved waste as applicable.

TEDS ID: MTW-50 **Timetable: > 5 Years**

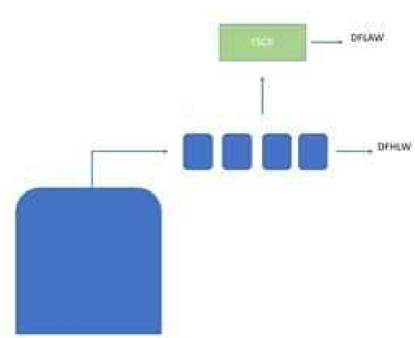
TECHNOLOGY NEED

Currently, single shell tank waste retrieval activities require an existing Double Shell Tank (DST) to serve as a waste receiver tank. Treatment systems like TCSR require multiple tasks to support operations. Future DFHLW process will also likely require a tank system to perform the needed functions. Existing DST space is limited in many areas of the site and is expected to become even more limited in the time frame before the Waste Treatment Plant (WTP) begins processing waste. A staging tank system that can support waste retrieval needs, DFLAW feed and DFHLW feed can provide a means to allow continued risk reduction along with provide multiple feed streams in support of direct feed processes. Coupled with a TCSR this system could also serve as a separation system that receives SST waste, processes the supernate to fee DFLAW and processes the sludge to feed DFHLW.

TECHNOLOGY SOLUTION

Developing of this type of tank system is a multi-phase activity. Initial efforts will focus on developing permitting, design, procurement, and construction strategies based on the retrieval, DFLAW, and DFHLW specific needs. After strategy development execution would follow a typical project life cycle with a tailored approach.

Examples of the equipment may include instrumentation, process equipment, and treatment systems including vapor abatement. The staging tank system could be configured to allow for time phases expansion based on mission needs. The initial system could support retrieval with planned expansion to support DFLAW and DFHLW as needed. This type of system would be particularly useful near SSTs Farms located in remote areas.



Feed Tank Flow Diagram

THREATS AND OPPORTUNITIES

TFIRR-0045-T: DST Failure in East Area

TFIRR-0046-T: DST Failure in West Area

TFIRR-0048-T: SST Failure in West Area

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Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

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Predicting Behavior of Mercury in EMF

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US DEPT OF ENERGY

TEDS ID: MTW-57 **Timetable: ≤ 5 Years**

Operating data from the 242-A Evaporator campaigns is used to predict operations in the Effluent Management Facility (EMF) evaporator. The behavior/impact of the higher mercury concentration on the new evaporator is not known

TECHNOLOGY NEED

Partitioning of mercury in low-activity waste (LAW) melter off-gas processes, wet electrostatic precipitator (WESP), and submerged bed scrubber (SBS), has not been experimentally determined. Data from laboratory-scale venturi scrubber testing was used to estimate the decontamination factor for the SBS; LAW off-gas processes were assigned a decontamination factor of one. An accurate decontamination factor for mercury in the LAW off-gas system is needed to determine the mercury concentrations of LAW condensate. Furthermore, the Hanford Tank Waste Operating System does not track mercury in the SBS/WESP off-gas condensate recycle. During direct-feed LAW (DFLAW), the mercury concentration is needed to accurately assess the impact on tank farm and the evaporator.

TECHNOLOGY SOLUTION

The approach is to update the assumed partitioning for mercury in the process models to allow better estimates for the condensate during DFLAW operations. Key considerations during the testing will include validation of HgCl2 as the mercury species in the LAW off gas, followed by small-scale and/or large-scale tests to determine mercury partitioning in the SBS and WESP. An assessment of the improved mercury partitioning on the remaining LAW off gas processes are planned to be performed and used to evaluate the impacts of the expected mercury levels during processing in the 242-A Evaporator.

Engineering-Scale Evaporator

THREATS AND OPPORTUNITIES

ETFOP-0059-T: Secondary Waste Form Uncertainty

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

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US DEPT OF ENERGY

Nitrosamine Monitoring and Reduction

TEDS ID: MTW-59 **Timetable: > 5 Years**

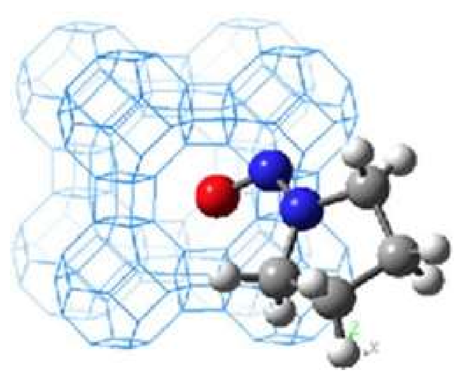
Implementation of commercial large-pore high-silica zeolites (HS series) in personal protective equipment for the removal of nitrosamines from the tank vapors can help protect tank farms personnel by reducing exposure to the hazardous constituents of the tank vapors and address short-term and long-term health concerns.

TECHNOLOGY NEED

The vapor resolution program calls for implementation of methods to anticipate, recognize, evaluate and control chemical hazards associated with ongoing emissions of tank vapors. The tank vapor is a complex mixture of reactive volatile organic chemicals, submicron aerosols, volatile metal and metalloid compounds, and other compounds. Nitrosamines, potential carcinogens, are present in the tank vapors due to the high concentrations of inorganic nitrogen-containing species (e.g., nitrate and nitrite) in the tank waste and their radiolysis degradation products, which readily react with organics in the tank waste. Any tanks or tank farms (e.g., AN Tank Farm) with high organics could contain increased nitrosamine levels.

TECHNOLOGY SOLUTION

Some commercial zeolites have been proven effective at removing nitrosamines from such complex vapor mixtures as tobacco smoke that contains over 5,200 identified chemicals, including several volatile nitrosamines ranging from small common to large nitrosamine derivatives. Zeolites are widely applied in industry as adsorbents and catalysts. It was reported that nitrosamines adsorb on zeolite not only by size/shape exclusion mechanism but mostly by means of the –N–N=O groups entering the zeolite channels similar to the mechanism of NOx adsorption to zeolites (Li et al. 2014, "Cleaning carcinogenic nitrosamines with zeolites"). This specific interaction is responsible for the selective uptake of nitrosamines by zeolites from complex vapors. Further, zeolites can catalytically cleave the –N–N=O functional groups of nitrosamines and destroy their carcinogenic ability.



THREATS AND OPPORTUNITIES

RPP-006: SST Retrieval System Performance Does Not Meet Requirements Due to Controllable Causes

Technology Maturation Level

Prototype

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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US DEPT OF ENERGY

Plutonium Particulate Criticality Safety Issue Resolution

TEDS ID: MTW-70 **Timetable: ≤ 5 Years**

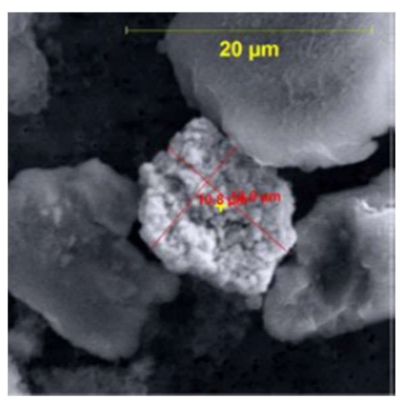
Pu-Bi compounds are not included in the inventory of plutonium particulates. They may be large and dense and could be present in the waste in more tanks than previously identified. Studies must be performed to determine the extent and density of Pu-Bi particulates.

TECHNOLOGY NEED

Criticality safety evaluation is required before waste that holds the larger inventories of particulate plutonium can be retrieved, mixed and transferred. Special concerns arise with the potential that the particulate plutonium-bearing waste in tank SY-102 might need to be retrieved under emergency conditions if that tank starts leaking. Tank SY-102 is one of the more vulnerable double-shell tanks (DSTs) for tank integrity and leakage issues. Retrieval options are limited because it is one of only three DSTs in the 200 West Area. The proposed work is
needed to definitively establish the tank farms inventory of particulate plutonium as necessary input to criticality safety evaluation, allowing retrieval of tanks such as DST SY-102.

TECHNOLOGY SOLUTION

Two tasks are identified in support of further establishing the particulate plutonium inventory:
1. Characterize the particulate plutonium in forms such as PuO_2, Pu Bi and Pu bi PO_4, determining particle sizes, densities and conditions of formation by advanced laboratory methods, such as transmssion electron microscopy (TEM).
2. Determine density and conditions of formation of the Pu Bi compounds by laboratory synthesis to match the TEM analysis. This testing is to understand whether compounds matching those expected to form in the waste can be synthesized under conditions such as in the bismuth phosphate process (i.e., B Plant, T Plant)



TEM Image Plutonium Particle

THREATS AND OPPORTUNITIES

TFIRR-0045-T: Tank Failure In East Area
TFIRR-0046-T: Tank Failure in West Area

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

3 Years - 4 Years

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Improve Best Basis Inventory Interface with TWINS Database

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US DEPT OF ENERGY

Improve the interface used for BBI updates and data access within the TWINS database.

TEDS ID: MTW-71 **Timetable: > 5 Years**

TECHNOLOGY NEED

Suggested Tank Waste Information Network System (TWINS) enhancements include:
- Search functionality
- Automated graphic production
- Simpler application for nonexpert users
- Ability to visualize current and historical BBI data
- Ability to compare inventory or concentrations values for specified analytes or radionuclides including the ability to search sample data by metadata.

For both BBI and TWINS, update to modern computer coding to allow streamlined revision and future upgrades as needed.

TECHNOLOGY SOLUTION

Initiate activity with a study to determine best software platforms and most value-added upgrades based on input from the Tank Waste Characterization Group and other data users. The study should also include a cost-benefit analysis for alternate platforms. Based on this information, a down-selection would occur and a budget and schedule would be developed. A modular approach would be utilized to develop and deploy upgrades.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

TFIRR-0045-T: DST Tank Failure in East Area
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Continuous Air Monitor Remote Observation

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US DEPT OF ENERGY

Provide CAM technology to minimize the need for operations and maintenance personnel to service the equipment during daily rounds

TEDS ID: MTW-72 **Timetable: > 5 Years**

TECHNOLOGY NEED

Continuous air monitors (CAMs) are inspected during daily surveillance rounds and weekly/biweekly maintenance rounds. This exposes numerous operations, maintenance, and safety personnel to radiation and industrial (self-contained breathing apparatus) hazards. Finding a solution to reduce or eliminate the need for daily surveillance rounds and limiting the number of farm entries for maintenance would reduce worker exposure and improve exposures to as low as reasonably achievable. In addition, the method to analyze, determine, and report on emissions monitoring is time-intensive; having an automated system to analyze emissions would improve worker efficiency.

TECHNOLOGY SOLUTION

The proposed solution would provide the following improvements, at a minimum:

1. Remote indication of CAM operability.
2. Reduce the need for surveillance and service.
3. Real-time indication of whether or not within regulatory emissions requirements.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

WRPSC-0003-T: Tank Vapors Controls Impact Project Execution

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Measure Liquid Loss from Evaporation

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Tank breathing rates enable estimates of tank evaporation rates. Tank evaporation rate estimates are usually required when a tank leak assessment is performed. With tanks showing a large liquid loss or very small liquid loss this has not been a problem, but with SX tanks showing liquid losses in the 300 to 2,000 gal/yr range the breathing rate needs to be known unless there are other alternatives to evaluating if the tank is leaking.

TEDS ID: MTW-74 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

SX breathing rates are needed so as to be able to estimate liquid loss rates due to evaporation from SX tanks. Without knowing the breathing rates we likely can't conclude whether selected tanks are leaking. The alternative is to state we can't determine whether a tank is leaking or not, which is undesirable, and will eventually require a more restrictive means of waste retrieval. Tank SX-104 went through leak assessments or evaluation in 1988, 1998, 2008, 2009, 2011, and 2018. An alternative approach was implemented that indicated the liquid loss form SX-104 is the source of liquids coming into SX-106 via an old buried vapor manifold. Tanks in SX farm aren't planned for retrieval until 2028 per System Plan 8 base case. A retrieval process amenable for a leaking tank should be selected at least 3 to 4 years before that, so impacts to TPA milestones and waste retrieval projects would be years in the future.

TECHNOLOGY SOLUTION

Tank breathing rates for 12 tanks in 7 tank farms not including SX Tank Farm were measured in 1997-1998. The rates were measured by injecting inert gases (He and SF_6) into the tank head space, then taking periodic head space gas samples over time to observe the concentration decay. Breathing rates for 10 of 11 tanks excluding A and AX Tank Farms were in a nominal 2 to 3 cfm range, while those for three tanks in A and AX Tank Farms had rates in the 10 to 25 cfm range. One tank in BY Tank Farm was measured at 16 cfm, but it might have been affected by an exhauster used during saltwell pumping. The A and AX Tank Farms tanks are connected by large exhaust header, like those in the SX Tank Farm. These tests need to be performed for SX Tank Farm tanks, with some improvements necessary over the 1997-1998 tests.

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

TFIRR-0048-T: SST Failure in West Area

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Reduce or Eliminate Equipment Contamination

TEDS ID: MTW-75 **Timetable: > 5 Years**

When equipment contacts tank waste and becomes contaminated, it is difficult to handle and can severely limit engineering design options for waste contacting equipment. Reducing or eliminating contamination on small equipment or in-tank instrumentation would open up design options and decrease worker exposure.

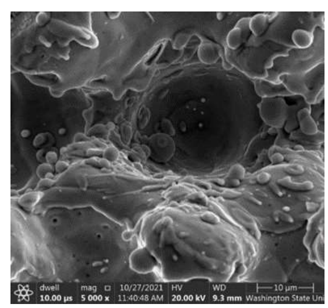
TECHNOLOGY NEED

Any technology that reduces or eliminates equipment contamination reduces the difficulty, time, and expense of dealing with waste-contacting equipment. It also reduces the dose workers receive, a critical as low as reasonably achievable (ALARA) principle. Application of special hydrophobic coatings to metallic equipment surfaces is used in the nuclear industry to reduce contamination. These coatings keep waste from sticking to the equipment, thus reducing contamination. These coatings can only be used in certain applications because they lack durability, lack adhesion to the substrate, or are chemically incompatible with the waste.

TECHNOLOGY SOLUTION

Etching nanostructures using femtosecond or nanosecond lasers creates a hydrophobic surface that is permanent and intrinsic to a metal surface. This new strong hydrophobic property could be applied in a cost-effective manner to small equipment or in-tank instrumentation. The following tasks would assess viability: 1. Verify that laser-treated metal surfaces effectively shed simulated waste. 2. Verify that the treated metal surface is not degraded by waste chemical constituents, exposure to radiation, erosion by insoluble waste particles, reasonable physical impacts. 3. Develop methods to speed application and reduce cost. 4. Apply treatment to a typical piece of waste-contacting equipment, expose to waste, then measure the contamination and compare to unexposed equipment with the treatment.

Water repelled by laser treated surface



Scanning Electron Microscope Surface Image at 5,000 times magnification

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

WRPSC-0009-T: Aging TOC Facilities & Infrastructure

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Using the Raman Spectroscopy, Laser- induced breakdown spectroscopy, multi- isotope process (MIP) method to develop a real- time, online monitoring system of tank waste

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

2 Years - 3 Years

Online Monitoring

TEDS ID: MTW-76 **Timetable: > 5 Years**

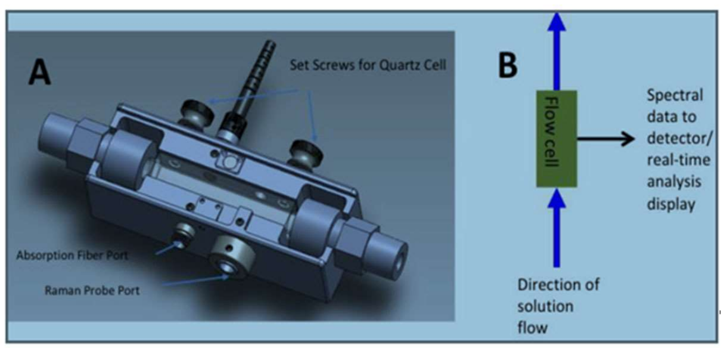
TECHNOLOGY NEED

Waste Treatment and Immobilization Plant and Direct-Feed Low-Activity Waste operations is expected to increase laboratory testing for feed qualification sampling, confirmation sampling, and process control. In order to prevent a bottleneck during sample analysis at the laboratory, a technology is needed to shorten the sampling and analysis turnaround time, while also maintaining exposures as low as reasonably achievable and increasing frequency of sampling.

TECHNOLOGY SOLUTION

A Raman method is a strong candidate for real-time,online monitoring because sodium salts represent greater than 90% of the supernate. Identification of these analytes using Raman is planned for the next 2 years. Exploring additional online monitoring methods to characterize important tank waste species is also planned.

The Raman method and system will be made of commercially available hardware and chemo-metric analysis software developed at Pacific Northwest National Laboratory. Testing will be carried out on tank waste simulants and real waste samples from the Radioactive Waste Test Platform.



a) drawing of cell holder b) schematic of how flow cell can be integrated

THREATS AND OPPORTUNITIES

222SL-0048-T: 222-S Laboratory Analytical Capabilities are Exceeded (DOE)

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In-Tank Volumetric Non-Destructive Evaluation

HANFORD SITE
US DEPT OF ENERGY

Development of primary tank bottom volumetric inspection capability addresses a current lack of available data to characterize the potential for degradation of the primary tank bottom within DSTs and single shell tanks. The product is expected to aid in determining the state of primary tank bottoms using non-visual examination methods.

TEDS ID: MTW-78 **Timetable: > 5 Years**

TECHNOLOGY NEED

An independent High-Level Waste Integrity Assessment Panel performed a review, and one of the issues identified was the inability of the double shell tank (DST) integrity program to predict a leak; this challenge was highlighted when a leak occurred in tank AY-102. At present, there is no visual or nondestructive examination (NDE) of tank bottoms where the leak occurred in tank AY-102. The method proposed here would supplement the current inspection method under development, which targets DST primary tank bottoms via refractory pad air channels. Inspection through the refractory pad air channels greatly limits the area of the tank bottom that can be reached due to using 24-in. risers for access and obstacles located in the DST annuals space.

TECHNOLOGY SOLUTION

Incorporate a volumetric NDE sensor into either a drill string or push rod for deployment though a riser, through waste, and pressed against the tank bottom. This method would utilize tank risers down to 4 in. in diameter for access to the tank. All other Hanford NDE development restricts access to just the annulus and the under primary tank air channels. Most NDE technologies can easily be fabricated into this size, allowing for the use of several different technologies; each analysis will target a 10-ft-diameter zone for analysis.

NDE Sensor

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Failure in West Area

TFIRR-0045-T: DST Failure in East Area

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HANFORD SITE
US DEPT OF ENERGY

Develop and test a four camera system with automated visual recognition to monitor a variety of manual gauges, indicators, alarm and status panel boards, and/ or sump levels that can automatically recognize visual trigger events and generate alerts. Integrate the associated software into an automated Site specific system.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

Automated Visual Recognition Wireless Remote Video Monitoring

TEDS ID: MTW-80 **Timetable: > 5 Years**

TECHNOLOGY NEED

Hanford Site tank farms contain a variety of workplace hazards, including those associated with chemical vapors emitted from the underground waste storage tanks. DOE workplace regulations specify that contractors must establish procedures to identify existing and potential workplace hazards and to assess the risk of associated worker injury and illness. One effective method to control such hazards is to reduce the time spent in the tank farm environment through the use of automated, remote control systems.

TECHNOLOGY SOLUTION

Remote wireless video has been successfully demonstrated and used for various applications at the Savannah River Site, using existing site wireless and wired network infrastructure. The video is displayed in real- me at a nearby or remote monitoring location (e.g., a facility control room), reducing the need for a worker entry to hazardous areas. A similar system specifically tailored to Hanford Site needs can provide a fully automated and easily retrofittable monitoring system to minimize the potential for Technology Maturation worker exposure to potential vapors.

Camera Monitor

THREATS AND OPPORTUNITIES

WRPSC-0003-T: Tank Vapors Controls Impact Project Execution

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US DEPT OF ENERGY

Radiation Tolerant Multi-Use Manipulator System

TEDS ID: MTW-81 **Timetable: ≤ 5 Years**

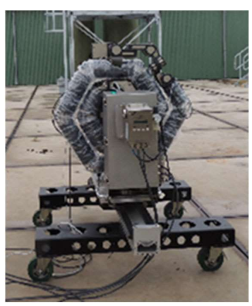
Viable technology for in-service Inspection of the Hanford DSTs is crucial to development and maintenance of an effective aging management regime. The snake-arm is a mobile, highly flexible, modular inspection and repair technology. The snake arm is a proven and viable technology to enable inspections using visual and other NDE techniques.

TECHNOLOGY NEED

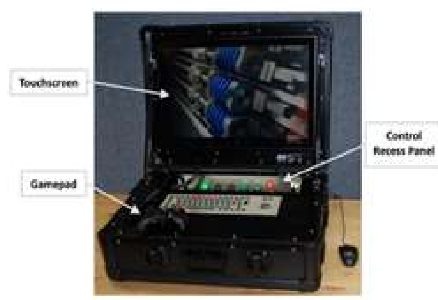
The complexity of the double-shell tank (DST) configurations is such that many of the structural elements and features of most concern to engineers and inspectors are located in inaccessible, hard to reach areas (e.g., DST annulus). In addition, the radiochemical conditions in the tanks are hazardous, ruling out manual access techniques. There is a pressing and immediate need for proven, robust and radiation tolerant remote systems to access the tanks to deploy cameras and other nondestructive examination (NDE) instrumentation to remotely inspect ion and gather data on the tank condition. The overall goal of this project is to demonstrate the use of a commercially available, radiation tolerant, multi-use manipulator system for repairing inspection tasks on the Hanford single-shell tanks and DSTs.

TECHNOLOGY SOLUTION

It is proposed that a proof-of-concept prototype snake-arm system be developed and demonstrated on a mock-up test facility at engineering scale. The test facility will mimic the operating environment in tanks, annulus and air channels based on input from ORP and the Waste Treatment and Immobilization Plant (WTP).



Prototype Snake-Arm



Arm Control Box

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Failure in East Area

TFIRR-0045-T: DST Failure in East Area

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Secondary Liner Bottom Damage Mitigation Technologies

HANFORD SITE
US DEPT OF ENERGY

Methods to alter environmental conditions beneath the secondary liner are required. Technology to dry out the under tank environment or otherwise make the environment protective of the carbon steel secondary liner bottom should be developed to ensure long-term availability of the DSTs.

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

TEDS ID: MTW-83 **Timetable: ≤ 5 Years**

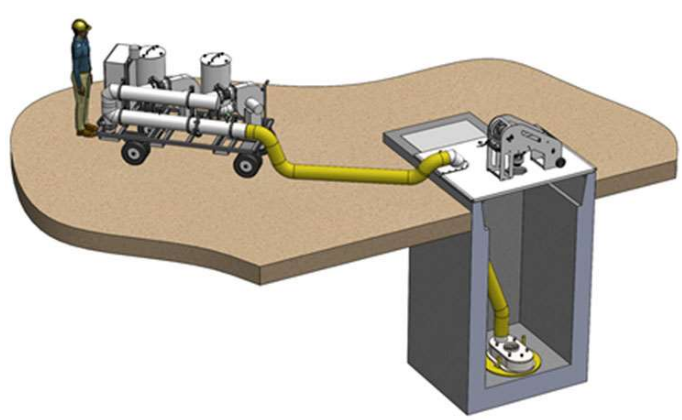
TECHNOLOGY NEED

Devices or systems to install on existing double-shell tank (DST) systems to cease moisture accumulation in the tertiary leak detection system and foundation space beneath the secondary liner. This technology needs to dry out the foundation space and/or otherwise prevent continued exposure of the secondary liner to corrosive conditions.

TECHNOLOGY SOLUTION

Initially, plug the cross-tie in tank AZ-102 with a special tool. Pending results, proceed with testing a slight positive pressure on the leak detection pit (LDP). Details in RPP-PLAN-60778, Double-Shell Tank Tertiary Leak Detection System Investigation and Mitigation Plan. Implementing a positive pressure test would encompass the following:

- Install a fan system on the LDP capable of maintaining the tank tertiary atmosphere (i.e., the space between the secondary liner and the concrete foundation/shell) at a slight positive pressure relative to ambient
- Monitor changes in water intrusion (via a camera on the LDP drain line and/or LDP liquid level).
- Monitor conditions in the LDP (i.e., verify slight positive pressure when the fan is on and slight negative when the fan is off, humidity, temperature).



Pit Pressurization and Monitoring System

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Tank Failure in West Area

TFIRR-0045-T: DST Tank Failure in East Area

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HANFORD SITE
US DEPT OF ENERGY

Pipeline Forensic Inspection Technology

Several pipelines have failed an encasement pressure integrity test. The Hanford Fitness for Service program has no readily deployable solutions to inspect and identify pipeline failure mechanism locations. A tool to travel through a pipeline and provide a condition assessment is needed to expand current understanding of pipeline failure phenomenon.

TEDS ID: MTW-84 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Visual and volumetric inspection capability delivered remotely through 2in. and 3-in. schedule 40 waste transfer lines in the tank farms is needed.

TECHNOLOGY SOLUTION

The proposed technology solution will enter a waste transfer line via a nozzle penetration of a pit. The device would be either self-propelled with a lightweight tether or driven from a push-pull system with a more rigid tether. The end of this inspection tool would be comprised of a visual inspection camera with pan/tilt functionality and lighting adjustment. Future iterations of the tool could include volumetric inspection sensors such as an eddy current probe or guided wave ultrasonic transducers.

Versatrax 100 for Inspection of Small Pipe and Ducts

Self-Propelled Pipe Crawler with Camera Attachment

THREATS AND OPPORTUNITIES

TFIRR-0039-T: SN-632 Failure

TFIRR-0038-T: SN-630 Failure

TFIRR-0037-T: SN-633 Failure

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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HANFORD SITE
US DEPT OF ENERGY

Surface profilometry is a commercially available technique used to extract topographical data from a surface. This can be a single point, a line scan or a full three-dimensional scan. The purpose of profilometry is to get surface morphology, step heights and surface roughness.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

Remote Surface Examination

TEDS ID: MTW-85 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Improved non-contact inspection methods that expand facility integrity knowledge are of high interest. Current noncontact methods deployed are limited to various visual inspection camera systems. Expansion of the inspection toolset to include a system such as compact laser profilometry system would allow better characterization of surface topography at target inspection locations. Possible applications for such a technology includes the concrete dome and liner wall of single-shell tanks, the region above the liquid surface within double-shell tank primary containment and the annulus of double-shell tanks. Use in these environments would provide additional understanding not currently possible with a camera, including size and depth for observed surface anomalies.

TECHNOLOGY SOLUTION

Profilometry inspection tools excel at fast, quantitative surface measurements of tank integrity. In order to use laser inspection tools, modification of a commercial tool would be required to allow for remote deployment and operation within target hazardous environments. Some testing of the systems capabilities would also be required to demonstrate performance expectations.

Compact Laser Profilometry System

THREATS AND OPPORTUNITIES

TFIRR-0048-T: SST Failure in West Area

TFIRR-0047-T: SST Failure in East Area

TFIRR-0046-T: DST Failure in West Area

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Protective Measures for Waste Transfer System Lines

HANFORD SITE
US DEPT OF ENERGY

Design an application of active systems to control encasement environmental conditions and prevent humidity and moisture accumulation are needed.

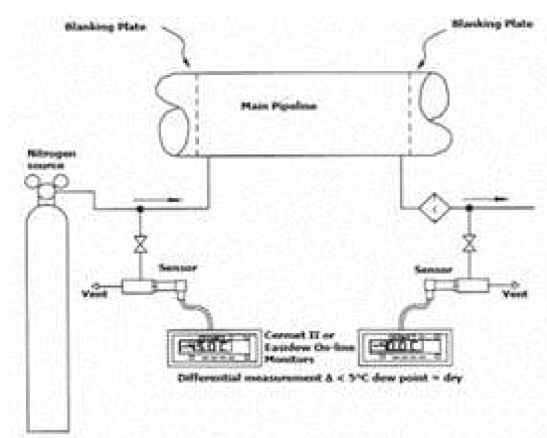
TEDS ID: MTW-86 **Timetable: > 5 Years**

TECHNOLOGY NEED

With the increase in number of transfers scheduled to support the startup of direct-feed low-activity waste (DFLAW) operations, further measures will need to be taken to ensure the integrity of the waste transfer lines. Transfer lines failures could cause schedule delays, resulting in large amounts spending to correct the problem.

TECHNOLOGY SOLUTION

Recent visual inspections from within transfer line test risers have shown various degrees of moisture presence and corrosion. In the case of several lines, the primary pipe or encasement have been discovered as failed via periodic encasement pressure testing. Design of these systems and leak detection practices have the potential to foster a corrosive condition within the encasement of the transfer lines by way of their atmospheric venting and drainage. Nitrogen purge drying is a viable option for preventing moisture accumulation in the annulus of the transfer lines.



Example Nitrogen Pipeline Purge Drying System

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

TFIRR-0039-T: SN-632 Failure

TFIRR-0038-T: SN-630 Failure

TFIRR-0037-T: SN-633 Failure

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Liquid Air Interface Sampler

HANFORD SITE
US DEPT OF ENERGY

Design and fabricate an interface sampler for use in Hanford tanks to identify the interface with an accuracy of ±1 in. After identification, the device will be able to obtain samples at interfaces. It will be designed to retrieve a 250 ml sample and to fit inside a 4-in. riser located at the top of the tank. The design will comply with ASTM standards and various codes/standards.

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

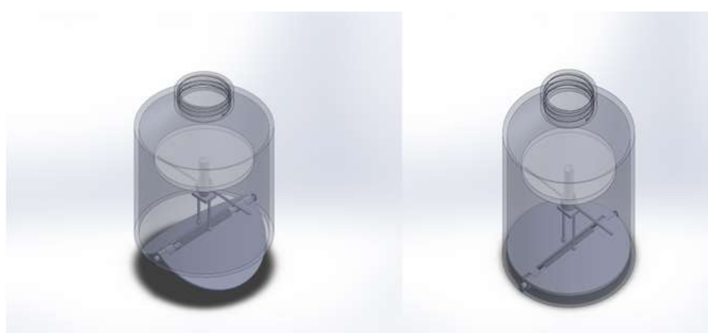
TEDS ID: MTW-88 **Timetable: > 5 Years**

TECHNOLOGY NEED

Due to the high ratio of insoluble materials to liquid within a tank, settling will naturally occur. Some materials that do not settle to the bottom of the tank float to the top. There are concerns that organics floating on the surface can lead to an increased risk of pitting at the liquid-air interface. Available Hanford liquid sampling technology cannot detect liquid interfaces nor successfully sample the surface of the liquid, and the depth accuracy is generally limited to about a few inches. A new way to sample liquid-air interfaces and liquid-liquid interfaces is needed.

TECHNOLOGY SOLUTION

A device needs to be able to fit a container through a 4-in. riser with 250 ml. The optimal device would be cylindrical to allow for a large surface area coverage but still be able to fit in the riser used for acquisition of samples. The objective is to keep fluid at the surface from being displaced and disrupted to allow for an accurate surface sample of the fluid. The top of the sampler is to be threaded to fit a regular 250ml bottle so that new transportation does not need to be created. The bottom of the sampler is to be a cylinder for large surface-to-volume ratio. The top of the device can be other shapes or a smaller diameter like a funnel. A funnel design is desirable because it would allow use of a plug to seal the top portion of the cylinder and keep the radioactive waste inside the container with a pour spout for testing in one unit. A closing hatch or door is needed to allow for an open bottom to acquire the sample without disturbing the fluid and causing turbulent flow into the fluid.



Interface Sampler Concept

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Tank Failure in West Area

TFIRR-0045-T: DST Tank Failure in East Area

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HANFORD SITE
US DEPT OF ENERGY

A remotely operated cleaning tool for concrete walls, waste transfer pits, ceiling cover blocks that are required to be painted with a SPC. This device must be able to thoroughly clean the SPC (i.e., Amerlock® 2/400 resin) without damaging it.

Remote Concrete Surface Cleaning Apparatus

TEDS ID: MTW-89 **Timetable: > 5 Years**

TECHNOLOGY NEED

A technology is needed to allow for remote cleaning of concrete walls, waste transfer pits and ceiling cover blocks that are painted with a special protective coating (SPC). Per WAC-173-303, SPC is required for concrete surfaces that may come in contact with tank waste (e.g., tanks vaults process pits, valve pits) must be inspected and repaired as necessary to maintain RCRA permit compliance. These surfaces will get dirty and contaminated due to occasional spills during operations. Before proper inspection and repair can occur the surfaces to be cleaned. Due to high radiation fields noted in most pits, the work associated with the cleaning and required coating repairs must be completed remotely (through the use of extension poles). Inspection of the cleaned and repaired surfaces is completed by visual inspection of high quality digital photographs.

TECHNOLOGY SOLUTION

The DST Annulus Floor Cleaning System, developed by Rolls-Royce for use by WRPS, is a remote operated cleaning tool designed to vacuum debris in DSTs annulus. It is believed that this technology could be further modified to be used in transfer pits and other RCRA facility locations to perform the necessary cleaning.

Typical Transfer Pit Configuration, Areas that Need to be Cleaned

Robotic Cleaner with Vacuum

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

TFIRR-0054-T: Pit Corrosion

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Water / Waste Volume Measurement for 242-A C-A-1 Vessel

HANFORD SITE
US DEPT OF ENERGY

Technology is needed to determine the water (condensate) level in the reboiler or water/waste level in the C-A-1 vessel. Ideally this device would mount to the tank exterior (on the sides). The technology solution must not degrade tank integrity.

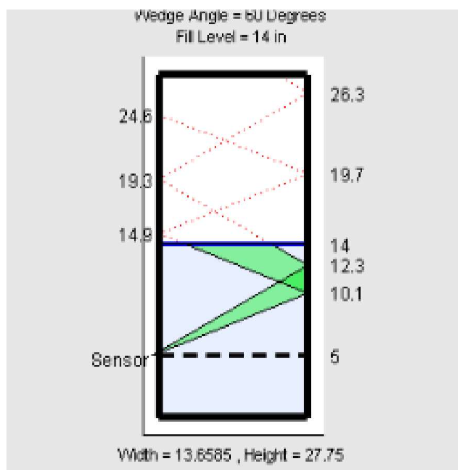
TEDS ID: MTW-90 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Existing instrumentation for monitoring liquid level is antiquated and unreliable; therefore, the need exists to develop a new approach.

TECHNOLOGY SOLUTION

The single transducer employs either multiple piezoelectric elements or mechanical impactors to generate acoustic burst signals with transverse or oblique propagation paths. The transverse propagation path is directly across the tank at the height of the transducer location. The time-of-flight of this echo depends mainly upon the transverse distance (vessel diameter), the liquid temperature and the acoustic properties of the liquid. The estimation algorithm relies on the markedly larger echoes that return from the corner reflectors formed at the interface of the liquid surface and the tank sidewalls.



Signal Schematic

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

242AE-0001-T: 242-A Aging Facility and Equipment Requires Unplanned Repair or Unanticipated Upgrades

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Tank - Side Waste Evaporation

HANFORD SITE
US DEPT OF ENERGY

A modular, transportable, evaporative system that minimizes risks associated with significant losses of existing 242-A evaporative capacity. Development and deployment plans to use a commercial thin-film evaporator technology modified for nuclear applications. The new WFE could support other potential future missions.

TEDS ID: MTW-91 **Timetable: > 5 Years**

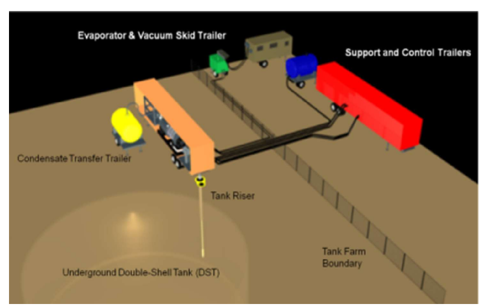
TECHNOLOGY NEED

Additional tank farm waste evaporative capability is needed to mitigate 242-A Evaporator failure risk, provide additional 242-A evaporation capacity, and supply new evaporative capacity to retrieve single-shell tank waste and secondary liquid waste from treatment processes. The proposed technology for this scope is a mobile wiped film evaporator system, relocatable to applicable tank farms. Key development scope involves use of a pilot-scale system to develop the technology followed by use of a full-scale system to validate scale-up of the system.

TECHNOLOGY SOLUTION

The wiped film evaporator (WFE) process uses a horizontal shell encased in a heating jacket. Within the horizontal shell is a rotor with blades that maintain a thin film on the shell wall where energy is transferred from the heating jacket promoting evaporation. The liquid moves horizontally through the shell and is continuously concentrated as volatile components are vaporized leaving non-volatile components that are discharged vertically through the bottom of the WFE. Vapor is discharged vertically through the top of WFE. The WFE shell system is operated under a vacuum allowing the system to perform at a lower temperature, reducing the amount of sensible energy to be transferred.

WFE Test Platform



Proposed Field Location

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

242AE-0001-T: 242-A Aging Facility and Equipment Requires Unplanned Repair or Unanticipated Upgrades

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HANFORD SITE
US DEPT OF ENERGY

Cs Online Monitoring for TSCR

TEDS ID: MTW-93 **Timetable: ≤ 5 Years**

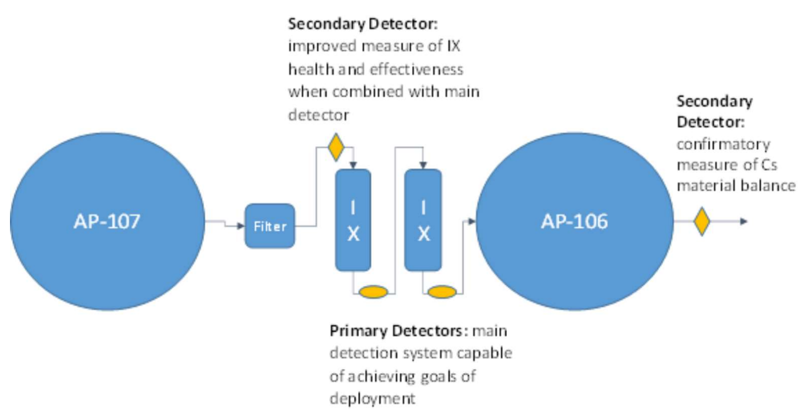
The goal of the work is to identify the appropriate COTS gamma detector(s), demonstrate performance under Hanford waste conditions, develop operational protocols for the user process interface and deploy a reliable and robust gamma detection system into the TSCR system and Low-Activity Waste Pretreatment System.

TECHNOLOGY NEED

Currently proposed cesium detection plans for the tank-side cesium removal (TSCR) system describe two continuous gamma detectors (for redundancy). This relatively simple design requires a lengthy counting period of nominally 1 hour to allow for the ingrowth of Ba-137m, the short-lived daughter of Cs-137 that is detected by gamma spectrometry, to attain secular equilibrium with the parent isotope. This delay is described in the plans as a slow fluid flow piping section with about 300 gallons of volume. This piping section holds the product stream for enough time to allow for 137mBa decay before the gamma level is analyzed downstream. The key design parameters are the vessel volume, dimensions, and baffle layout (see H-14-111252, General Arrangement Delay Tank, and RPP-CALC-62498 –TSCR Delay Tank Sizing.

TECHNOLOGY SOLUTION

A significant opportunity exists to consider the use of multiple detectors in an integrated feedback system that focuses on neutron radiographic testing (NRT) prediction of the tank AP-106 cesium content, rather than a conservative ion exchange (IX) column cesium breakthrough trigger. Leverage existing staff experience and capabilities at Pacific Northwest National Laboratory (PNNL) in nuclear detection, especially in the area of online process monitoring; a robust near-real-time monitoring solution (resistant to affects from bubbles and other process upsets) can be developed based upon commercial-off-the-shelf (COTS) technologies.



Multiple Detectors in an Integrated Feedback System

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

222SL-0009-T: 222-S Laboratory Analytical Capabilities are Exceeded

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CHIEF TECHNOLOGY OFFICE

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HANFORD SITE
US DEPT OF ENERGY

Wearable robotics are intelligent, powered, body support systems, capable of transferring heavy loads; for example, relief of the weight of air bottles from the spine to the support system.

Enhance Worker Capabilities

TEDS ID: MTW-96 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Technology is needed to enhance worker capabilities allowing safer and more efficient work. Currently, tank farm workers experience repetitive movements, such as going up and down stairs, and lifting heavy objects. Technology is needed to enable work to be less tiring, and dangerous. Most applicable; Tank farm workers, including firefighters, must regularly wear air bottles, such as self-contained breathing apparatus (SCBA) rack, or heavy packs. These heavy loads place a lot of strain on the body's spine, especially when crouching, kneeling, or carrying heavy loads. Transfer of heavy loads from the spine to the Exoskeleton could protect tank farm workers from the strain of added weight, such as SCBA systems.

TECHNOLOGY SOLUTION

Many systems are available, the two systems that are currently of interest for the Tank Farm Operator Contractor. The first, the Exoskeleton is a battery powered, lower-body exoskeleton fitted with artificial intelligence (AI). Technology designed to augment human strength and endurance by taking stress off the lower back and legs. It provides additional leg support for physically demanding tasks. The system provides support for the lower body, reducing the burden on a user's knees and leg muscles. Technology makes it easier to perform intensive activities, such as:

- Picking up heavy loads
- Moving on stairs or inclined surfaces
- Prolonged crouch or lowered posture

The Exoskeleton AI reads Exoskeleton sensors to determine how a user is moving. Actuators then apply torque to the user's knee joints to support their movements. This results in less muscle strain and more endurance.

Tank Farm worker calibrating Exoskeleton

Exoskeleton supporting Tank Farm worker wearing SCBA

THREATS AND OPPORTUNITIES

WRPSC-0012-T: Personal Protective Equipment (PPE) Availability Impacts Field Work Execution

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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CHIEF TECHNOLOGY OFFICE

washington river protection solutions

Continued Need for Improving Tools for Tank Farm Projects

HANFORD SITE
US DEPT OF ENERGY

Hand-held, self-positioning laser scanning system that includes scanner, computer, 3D printer, and software. Capable of 3D scanning (colors and surfaces) and printing of real-life objects.

TEDS ID: MTW-97 **Timetable: > 5 Years**

TECHNOLOGY NEED

Technology is needed to shorten the time needed to make onsite tools. Significant production time is required to fabricate custom tools for tank farm use. Human errors are experienced with the current manual field measurements and data transfer.

TECHNOLOGY SOLUTION

A three-dimensional (3D) laser scanner can reduce custom tool engineering, design, production/fabrication time for tank farm custom tools. Laser scanning reduces the manual development process of creating a 3D model of the field condition. Field scanning and data transmission reduces human errors experienced with manual data collection and transfer. Hand-held 3D scanners are light weight, mobile, and can be used anywhere to ensure a smooth information capturing process without manual field measurements or having to relocate objects to a particular place for data gathering. Laser 3D scanning reduces human errors. It is a simple point and shoot system that takes precise measurements in high resolution, resulting in 3D output. Selection of a commercially available model that can be modified to use on the Hanford Site is the proposed solution.

Hand-Held 3D Laser Scanner

THREATS AND OPPORTUNITIES

WRPSC-0011-T: Unexpected Field Conditions Encountered (TOC)

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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Long-Reach Robotic Tool for Waste Storage Tank Pits

HANFORD SITE
US DEPT OF ENERGY

A programmable robotic type of mechanical arm, with similar functions to a human arm that would enable remote manipulation of Tank Farm equipment.

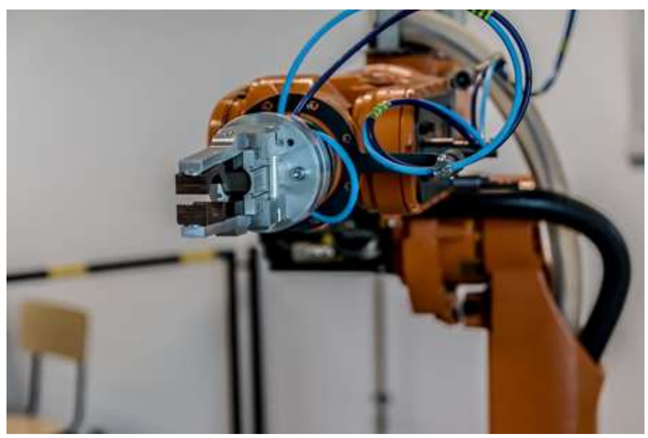
TEDS ID: MTW-98 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Tank Farms operations need remote operational support to reduce worker exposures to hazardous conditions, and confined space hazards. Tank Farms needs remotely operated Robotic to perform operational and maintenance tasks such as valve manipulation, welding, surveys, etc.

TECHNOLOGY SOLUTION

A programmable robotic type of mechanical arm, with similar functions to a human arm would enable remote manipulation of Tank Farm equipment, such as valves. Robotic tool could be fitted with multiple end effectors for the performance of various tasks. A mobile robotic tool provides the flexibility for use throughout the Tank Farms.



Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

WRPSC-0002-T: Resources Not Available when Required

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Tank Farm Smart Operating Procedures

HANFORD SITE
US DEPT OF ENERGY

The existing Tank Farm Operations support software, eSOMS, would be either upgraded or replaced to include all operating procedures. The system will be "smart", enabling tank farms operators to automatically record and enter readings obtained during the performance of operating procedures.

TEDS ID: MTW-99 **Timetable: > 5 Years**

TECHNOLOGY NEED

Tank farms operators record measurements by using the Rounds process as identified in relevant tank farm procedures. The eSOMS software, also known as E-Rounds, facilitates automated process at the tank farms. The current tank farm operating process is comprised of both a mobile application (rounds application) and a web application, the latter of which is accessed through a desktop browser. This system is partially automated and does not include all operating procedures. Operators automatically record and manually enter readings from some of their procedure rounds, saving time when compared with paper Rounds. However, the system needs to be fully automated to include automatic entry of readings from the operator rounds for all operating procedures. This improve efficiency and also reduce errors associated with manual transfer of data and information.

TECHNOLOGY SOLUTION

A fully automated "smart" procedure system would enable efficient tank farms operations. The current E-Rounds would be upgraded or replaced with a smart system that includes all operating procedures. The automated system would be accessed via portable computers/tablets. With the automated smart system, tank farms operators would complete all procedures electronically as procedures are performed in the field. The electronic system would walk operators through each procedure step, not allowing the operator to proceed to the next step until the previous step is completed. Human errors attributed to manual data entries would be eliminated. The electronic data would be easier to store, retrieve, generate reports from and support near-real-time monitoring at the tank farms.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

WRPSC-0010-T: Complex Integration of Field Work

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C.2 Retrieve Tank Waste

The following are the one-page catalog sheets of the balance of the RTW TEDS.

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HANFORD SITE
US DEPT OF ENERGY

Remote Tank Farm Above Ground Inspections

TEDS ID: RTW-03 **Timetable: > 5 Years**

Existing technology could be modifted to safely inspect the Tank Farms remotely. Examples include drones with attached cameras, and cable-mounted cameras

TECHNOLOGY NEED

During construction and retrieval operations, tank farm inspections are required, creating radiation exposure and other safety hazards for personnel. Personal protective equipment required for vapor safety, such as self-contained breathing apparatus, has created other worker safety issues. Additionally, the time and cost associated with manned entries is significant. The ability to conduct remote monitoring, from the Operations control trailer, would be beneficial. Ideas for remote field inspection include: drones, static-mounted cameras, mobile wire-mounted cameras, and remote operated vehicles.

TECHNOLOGY SOLUTION

Subject matter experts shall search for available solutions using the Expression of Interest {EOI} process. Ideas for remote field inspection include drones, static-mounted cameras, mobile wire-mounted cameras, remote-operated vehicles, or in-farm testing.

Drone with Onboard Camera

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

WRPSC-0011-T: Unexpected Field Conditions Encounterd

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Near Tank Soil Sampling

HANFORD SITE
US DEPT OF ENERGY

Characterization of contaminated soil is a step to the remediation and closure of tank farm waste management areas. A prototype beta detection probe designed for in-situ detection of beta-emitting soil contamination would be helpful

TEDS ID: RTW-04 **Timetable: > 5 Years**

TECHNOLOGY NEED

Appendix I of the Tri-Party Agreement requires characterization of contaminated soil as a step toward the remediation and closure of tank farm waste management areas. One of the most important risk contributors in soil is technetium-99, a beta emitter. Current methods for identifying technetium-99 contamination involve removing soil samples and performing laboratory analysis. In situ identification can reduce cost and time associated with soil characterization in all tank farms.

TECHNOLOGY SOLUTION

One option under consideration is a prototype that has been previously designed for deployment with a direct-push unit. A survey of other potential methods is planned. A down-selected technology can then be configured and deployed in coordination with the other soil characterizations.

Direct-Push Prototype Beta Detection Probe

Technology Maturation Level

Prototype

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

AAXRC-0049-T: Old Spill Sites During Excavation

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Post Waste Retrieval Updates to WMA CPA and Long-Term Maintenance

HANFORD SITE
US DEPT OF ENERGY

Identify areas where new information or technology maturation will provide the greatest future benefit (e.g., altered retrieval requirements, affected closure cap design). Information will be integrated into Rev. 1 of the WMA C PA and into the assessments being developed for other WMA closures.

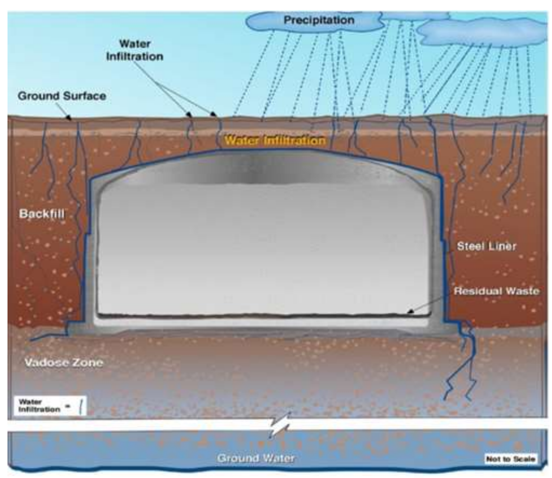
TEDS ID: RTW-07 **Timetable: > 5 Years**

TECHNOLOGY NEED

This technology is needed to support future update of the Waste Management Area C {WMA C} Performance Assessment {PA} {RPP-ENV-58782}, development of other WMA PAs, selection of closure technologies and future retrieval planning.

TECHNOLOGY SOLUTION

A review is planned to support future update of the WMA C PA, development of other WMA PAs, selection of closure technologies and future retrieval planning:
- Testing on residual waste samples from tanks to better define waste release characteristics {this task would not pay for sampling, just for the extra tests}.
- Sampling and testing of concrete samples from tank walls of ancillary equipment, to learn more about tank concrete degradation.
- Evaluation of grout development and testing to better define waste release characteristics for final closed tanks.



Long-Term PA Maintenance Parameters

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

+ 4 Years

THREATS AND OPPORTUNITIES

CFY21-0001-T: Delays in C Farm Closure Criteria

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Dry Retrieval Systems

HANFORD SITE
US DEPT OF ENERGY

A dry sludge retrieval system is needed for hard packed wastes in leaking SSTs. An alternative retrieval technology is needed by 2022 to begin supporting waste retrievals from A and AX Tank Farms.

TEDS ID: RTW-08 **Timetable: ≤ 5 Years**

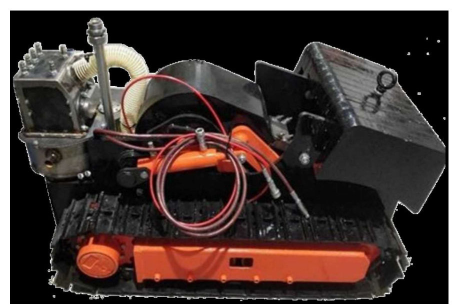
TECHNOLOGY NEED

A technology is needed for retrieving solids from Hanford Site tanks that contain primarily solids (sludge, salt cake, and hard pan). An alternative retrieval technology is needed by 2024 to begin supporting waste retrievals from A and AX Tank Farms. In many single-shell tanks (SSTs), it is undesirable to use sluicing liquids to break up and remove waste due to the known or suspected reduced integrity of the tanks.

TECHNOLOGY SOLUTION

Design and fabrication of a modular dry waste retrieval system will remove hard-packed waste in tanks using no introduced liquids. A prototype of waste removal devices and transport systems will be developed in a modular manner. Approach will build upon other remote solutions. The system will leverage industry knowledge and experience allowing an integrated system to be tested and a prototype to retrievals in FY23.

3 Passes on 7:1 Mix Concrete



Phase III MWGS

Technology Maturation Level

Prototype

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

THREATS AND OPPORTUNITIES

AAXRC-0012-T: Delays in A-104 and A-105 Retrieval Due to Technology Development

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HANFORD SITE
US DEPT OF ENERGY

Evaluate Back-Up Options for HLW Delivery from the Tank Farms

TEDS ID: RTW-15 **Timetable: ≤ 5 Years**

The technology required to ensure particle size requirements for high-level waste feed are met is currently available, but may not be in a configuration required for deployment in Hanford Site tanks. Work to be performed here would take the technology to Technology Readiness Level 9.

TECHNOLOGY NEED

The waste acceptance criteria limit on maximum particle size in high-level waste feed to the Waste Treatment and Immobilization Plant Pretreatment Facility is 310 µm. If tank waste characterization and staging (TWCS) is unable to provide feed, a size segregation and/or size reduction technology could be deployed in the double-shell tanks and support feed delivery to the Pretreatment Facility. This could be accomplished by deploying the TWCS selected technology in the double-shell tanks or using the double-shell tank mixer pumps and an appropriately selected transfer pump elevation to perform the necessary particle size segregation.

TECHNOLOGY SOLUTION

The development approach is twofold: (1) through laboratory testing of a modified approach using concentrated supernatant and (2) through small-scale tank testing to confirm that the reaction dynamics are functional and understood for a full-scale tank. The process development would occur in a National Laboratory and may be followed up by a demonstration on actual waste in the 222-S Laboratory. In addition assessment of ability of segregated solids to “re-agglomerate” after size separation should be considered. Most useful would be the identification of property guardrails that would assist operations to avoid regimes were particle aggregation/agglomeration would occur.

Small-Scale Testing Platform

THREATS AND OPPORTUNITIES

DFLAW-0206-T: Secondary Solid Waste Management Less Than Adequate (Tank Farms and WTP)

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

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Develop an Integrated HLW Feed Qualification Plan

HANFORD SITE
US DEPT OF ENERGY

An integrated feed qualiftcation program will allow for identiftcation of gaps in capabilities and support an assessment of technology options that most appropriately ftll the need.

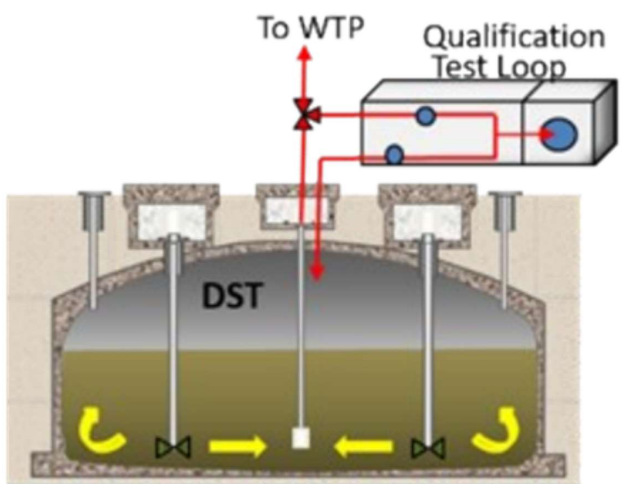
TEDS ID: RTW-16 **Timetable: > 5 Years**

TECHNOLOGY NEED

The integrated high-level waste feed qualification program should be mature and completed long before the feed qualification samples are collected. To ensure the program is developed and operationally ready, tank farm characterization and/or simulant testing elements need to be performed well in advance of the operational need date.

TECHNOLOGY SOLUTION

The development approach is to jointly develop an integrated Waste Treatment and Immobilization Plant Tank Operations Contractor feed qualification program patterned after the operational program implemented at the Defense Waste Processing Facility. This program will identify technology gaps and needs that will then be evaluated for the preferred path forward.



Sampling Qualification Test Loop

THREATS AND OPPORTUNITIES

DFLAW-0206-T: Secondary Solid Waste Management Less Than Adequate (Tank Farms and WTP)

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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HANFORD SITE
US DEPT OF ENERGY

Assess Deep Sludge Pump Reliability for DST Mixer and Transfer Pumps

TEDS ID: RTW-17 **Timetable: ≤ 5 Years**

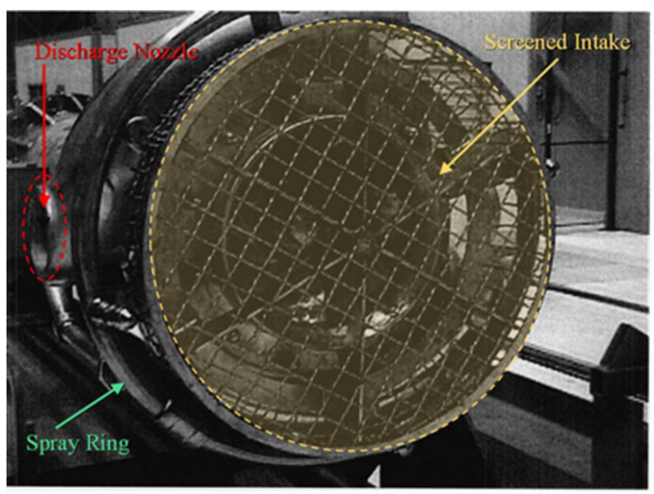
Determine the ability to stop and restart pumps in high-level waste feed delivery tanks.

TECHNOLOGY NEED

The need is to test the limits of performance of full-scale mixer and transfer pumps to determine gaps and then develop technology-based solutions to ensure reliability when equipment is deployed in deep sludge conditions.

TECHNOLOGY SOLUTION

A program plan/engineering assessment will be developed that will consider the value and use of small-scale testing as a predecessor to full-scale testing. Work will include reviewing mixer pump test results performed for Savannah River Site and Hanford Site tanks. The next step would include obtaining scaled testing capability as recommend by the program plan. Note that the test facility may be available/capable of supporting other technology development needs.



Inlet of a Deep Sludge Mixer Pump

Technology Maturation Level

Prototype

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

TFIRR-0029-T: Pump Failure

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HANFORD SITE
US DEPT OF ENERGY

Improved Heat Removal for AW and AN Tank Farms TSR Heat Limits

Develop a twofold approach that uses models and engineering evaluation of ventilation system heat removal capacities, then evaluate alternate mixer pump configuration that use more but smaller pumps to mobilize waste, resulting in less heat input.

TEDS ID: RTW-18 **Timetable: > 5 Years**

TECHNOLOGY NEED

There is a risk that AW and AN Tank Farm tanks may exceed Technical Safety Requirement heat limits. Either improved heat removal or reduced heat input is needed. An evaluation of the trade-off to improve heat removal by new or modified systems or reduce heat input by changing the mixer pump configuration may identify new technologies to resolve the heat load risk.

TECHNOLOGY SOLUTION

The development approach is twofold:

1. Through modeling and engineering evaluations of ventilation system heat removal capacities
2. Through evaluation of alternate mixer pump configurations that use more but smaller pumps to mobilize the waste.

This twofold approach should result in less heat inputs. The modeling will be similar to previous thermodynamic modeling of double-shell tank systems. The mixer pump configuration testing will utilize small-scale effectiveness and will be combined with thermodynamic modeling to estimate the overall hear balance.

Technology Maturation Level

Prototype

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

TFIRR-0045-T: DST Tank Failure in East Area

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HANFORD SITE
US DEPT OF ENERGY

Removal of SR-90 and TRU

TEDS ID: RTW-19 **Timetable: > 5 Years**

In Double Shell Tanks, Strontium-90 and Transuranic precipitation can be performed in the tank farms rather than in the WTP Pretreatment Facility to increase mission efficiency.

TECHNOLOGY NEED

While a process has been developed for implementation in the Waste Treatment and Immobilization Plant (WTP), its implementation complicates and reduces the efficiency of the flow of material through the Pretreatment Facility. This process may be performed efficiently in DSTs, but the current process in the pretreatment requires dilution of DST waste to 5M sodium but the tank farm would prefer to do this strontium-90 (Sr-90) and transuranic (TRU) removal at a higher molarity to conserve space if the removal process were to be performed in the tank farm. The method of removing Sr-90 and TRU should be optimized for more concentrated solutions so that it can be implemented efficiently in the tank farm.

TECHNOLOGY SOLUTION

The development approach is threefold:

1. Laboratory testing of a modified approach using concentrated supernatant.
2. Small-scale tank testing to confirm that the reaction dynamics are functional and understood for a full-scale tank. The process development would occur in a National Laboratory and may be followed up by a demonstration with actual waste in the 222-S Laboratory. Development will include review and incorporation of lessons learned from monosodium titanite strikes at the Savannah River Site.
3. Consider use of the Radioactive Waste Test Platform for testing with real waste.

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

TFIRR-0092-T:

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Improve ESP-a Thermodynamic Modeling Program

HANFORD SITE
US DEPT OF ENERGY

WRPS already has ESP in use. However, the database of ESP could be continuously improved as need arises and more data is available.

TEDS ID: RTW-21 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The ESP modeling results are routinely used to 'process decision making' such as how much water or caustic to add during waste retrieval, what solids form, etc. The current ESP program could use some improvements on areas such as aluminum solubility and metal/metal oxides/hydroxides dissolution in oxalic acid and in caustic. It has been found that ESP consistently under-predicts the solubility of aluminum or oxalate. Therefore, it is likely that we will require custom databases for these species. Also, systems of Na-NO3-NO2 and Na-F-PO4 could benefit from improved prediction capability. That is possible only when more experimental data is collected and incorporated into the database.

TECHNOLOGY SOLUTION

The ESP developer, OLI, could be commissioned to investigate and develop needed customization of the ESP database. Data collection will be performed as necessary if literature research finds experimental data lacking.

OLI Flowsheet

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

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HANFORD SITE
US DEPT OF ENERGY

A method of unplugging transfer pipelines at the tank farms is needed. Methods of unplugging to include mechanical devices or pulsed fluidic systems could provide a functional solution to free obstructions.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

Waste Transfer Pipe Unplugging

TEDS ID: RTW-23 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The effect of a plugged transfer line can be devastating. It can impact all manner of waste transfers including tank retrieval efforts, feed to the 242-A Evaporator, cross-site transfers and feed of waste to the Waste Treatment and Immobilization Plant. While measures are taken to mitigate the potential for a plugging event, including maintaining critical velocities of flow and using heat trace to prevent cooling and precipitation, plugging events have historically occurred. The implications of a plug that cannot be removed are equivalent to a failed transfer line that must be removed from service. This puts a strain on the system's ability to support the mission efficiently and cost effectively.

TECHNOLOGY SOLUTION

Evaluation of market options and/or technology development of a unique solution for pipeline unplugging of the various primary pipe configurations throughout the tank farms waste transfer system would address the risk associated with the potential loss of a plugged transfer line.

Pipeline

THREATS AND OPPORTUNITIES

TFIRR-0011-T: Tank/Infrastructure Failures Prohibit Waste Transfers from DSTs in West area

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Void Filling to Prevent Collapse

HANFORD SITE
US DEPT OF ENERGY

This technology is being implemented now to develop formulations for highly-flowable grout for small and complex structures and bulk fill grout for large and less complex structures.

TEDS ID: RTW-25 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

This technology is needed to support Waste Management Area (WMA) C closure required under Tri-Party Agreement (TPA) Milestone M-045-83. The information to be gathered from these activities is needed to complete closure of the C-200-series tanks and larger ancillary equipment voids from: pipeline encasements, catch tanks, vault tanks, diversion boxes, as one of the first steps in application of the Incremental Closure Approach for WMA C and has applicability to other tank farm waste management areas.

TECHNOLOGY SOLUTION

Final development and testing of highly-flowable grout and bulk fill grout are designed to provide data needed to reach agreement among TPA stakeholders and WRPS for closure of the diversion boxes, 200-series tanks, and vault-tank structures within WMA C. The amount of testing required to achieve this purpose will be determined through meetings and discussions among the entities involved. The overall approach is as follows:

1. Conduct a review of grouting performed at other facilities and sites {e.g., 221-U Plant, Hanford 300 Area, other DOE sites} since development of RPP-RPT-41550, Closure Demonstration Grout Test Report.
2. Work with DOE, WRPS and Ecology staff to establish expectations and data needs.
3. Develop an initial set of grout formulations and sealing technologies to test.
4. Test initial grout formulations and sealing technologies at bench scale.
5. Refine formulations and conduct additional bench scale testing if needed.
6. Conduct large-scale testing using a mocked-up pipe encasement{s}.
7. Report test results.

THREATS AND OPPORTUNITIES

CFY21-0022-O:

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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CHIEF TECHNOLOGY OFFICE

washington river protection solutions

Improved Solubility Modeling

HANFORD SITE
US DEPT OF ENERGY

Currently, solubility modeling is able to predict some precipitation with moderate accuracy in waste simulants containing only a select list of analytes. The purpose of the proposed tests is to provide the underlining solubility data needed to adjust the model parameters so that the model can predict precipitation with acceptable accuracy.

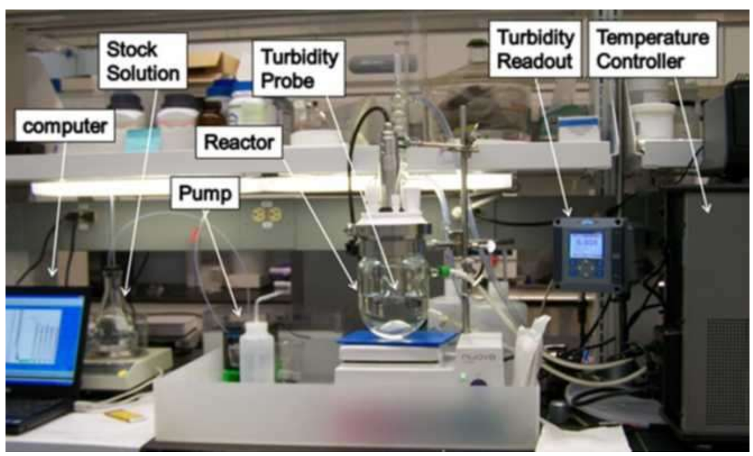
TEDS ID: RTW-27 **Timetable: > 5 Years**

TECHNOLOGY NEED

There are several key components, such as Aluminate, Gibbsite, Oxalate, and Fluoride in Hanford Site tank waste the solubility of which can be a driver in long-term mission planning. Many external groups have recommended improvements in the chemistry modeling used in long-term mission planning simulations. Having inadequate chemistry can lead to inadequate predictions of processing problems due to line or equipment plugging, movement of tank waste, mission end dates, and the quantities of immobilized low-activity waste and immobilized high-level waste.

TECHNOLOGY SOLUTION

Solubility experiments need to be conducted to better understand tank chemistry. Simulants could be used with the potential for real waste samples being used as well. Solubility experiments must be conducted to a high level of precision and accuracy so that the data can be used to develop thermodynamic models.



Laboratory Setup

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

DFLAW-0206-T: Secondary Solid Waste Management Less Than Adequate (Tank Famrs and WTP)

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

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US DEPT OF ENERGY

In-Tank Sampling Technologies for Plutonium Particles

TEDS ID: RTW-31 **Timetable: > 5 Years**

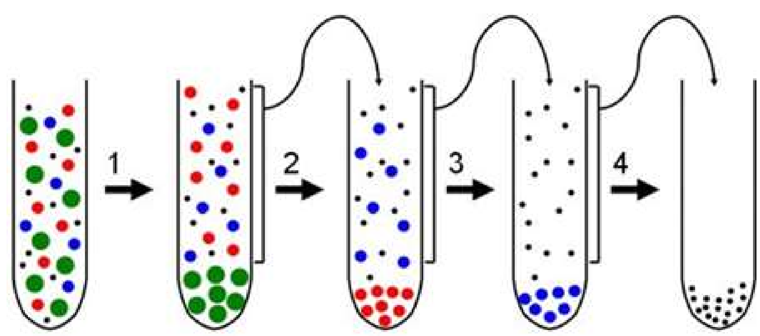
A waste feed delivery strategy is needed that includes sampling and detection of plutonium particles that addresses potential criticality concerns.

TECHNOLOGY NEED

While numerous reports, such as RPP-RPT-50941 and RPP-RPT-54469, discuss the particulate plutonium inventories in the tank farms, uncertainties remain about the processing origins, conditions of formation, distributions and quantities of this plutonium {especially the plutonium-bismuth particles}. Criticality safety requirements mandate providing capabilities to detect and characterize the particulate plutonium that will be retrieved, blended and transferred in the waste feed to the Waste Treatment and Immobilization Plant {WTP}. The tank farms do not currently have the capability to sample for plutonium particulates with the representativeness and accuracy necessary for compliance with the criticality safety requirement.

TECHNOLOGY SOLUTION

Working with a National Laboratory, complete the problem definition {sampling locations and required accuracy}. With a mature problem definition, identify potential technologies that could be applicable and down-select to the most promising candidate{s}. Test these technologies, for example by work at small-scale to determine which technology should be tested at larger scale. Perform qualification testing at full-scale to validate that the technology meets the performance requirements.



Differntial Centrifugation

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

+ 4 Years

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Criticality Safety Control Strategy for Particulate Plutonium

TEDS ID: RTW-32 **Timetable: > 5 Years**

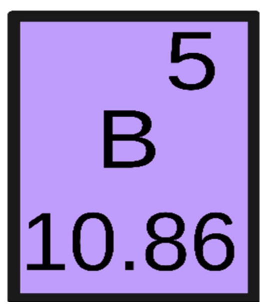
Develop the technology for delivering soluble neutron poisons into those tanks having high particulate plutonium inventories as a criticality safety control strategy. Demonstrate the chemical stability and e.ffectiveness of the neutron poisons.

TECHNOLOGY NEED

Development of the technology to deliver neutron poisons will provide a criticality safety control strategy for retrievals of waste from tanks such as SY-102, TX-109, and TX-118. Development will address outstanding issues of chemical stability of the neutron poisons in the caustic waste environment. Design criteria for monitoring instrumentation that arise from the ANSI/ANS-8, Fissionable Material Outside Reactors, standard on soluble poison additions will also be addressed as required under DOE O 420.1C, Facility Safety.

TECHNOLOGY SOLUTION

Technology development will require a combination of waste experiments and computational fluid dynamics modeling as well as monitoring instrumentation design development.



Potential Neutron Poison

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Tank Failure In West Area

TFIRR-0048-T: SST Failure in West Area

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Technologies are needed to remove residual waste from non-leaking tank. This could include new technologies or modifications to existing technologies.

Remove Residual Solids in Non-Leaking Tanks

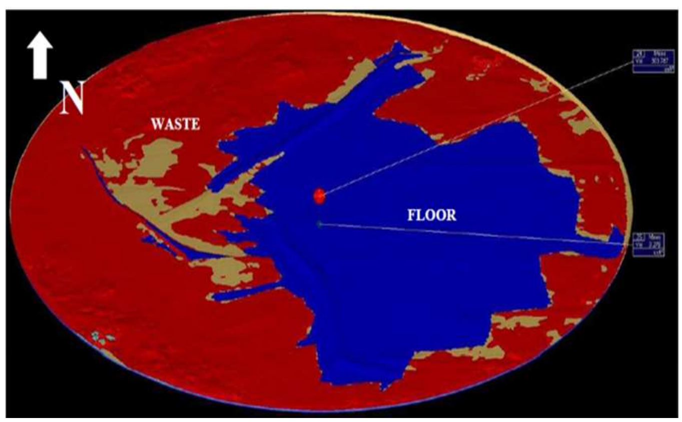
TEDS ID: RTW-34 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Modifications to existing technology or new technologies are needed to more effectively remove residual waste from non-leaking tanks. Closure standards require a minimum amount of remaining solids in the tank bottom. These solids accumulate in hard to reach areas of tank bottoms.

TECHNOLOGY SOLUTION

New technology will focus on retrieving the hard to reach residual waste that current sluicing methods struggle to retrieve. Smaller technology that can be installed down small diameter risers is desirable because these risers are more available. The development approach for this effort includes: preparation of a specification, down selection, awarding a contract, and fabrication and testing.



Tank 241-AX-102 Waste Surface Laser Scan (Floor Visible Locations)

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

AAXRC-0016-T: Excessive Equipment Failures (other than pumps)

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Risk Informed Tank Retrieval Modeling Optimization

TEDS ID: RTW-39 **Timetable: ≤ 5 Years**

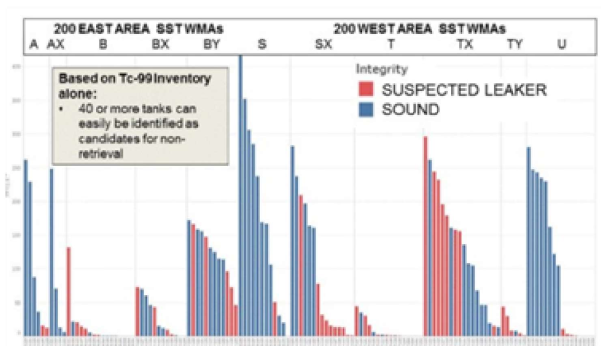
This optimized risk model enhances the risk outcomes from the system model by including other relevant factors (i.e., waste volume, leak status, waste type, worker impacts from retrieval, and cost of retrieval) which will reduce the overall costs of tank retrieval and the management of space in the double- shell tank system easier

TECHNOLOGY NEED

A volume-based retrieval standard has been used as defined in the Tri-Party Agreement and Consent Decree. Single-shell tanks {SSTs} vary significantly in their risk characteristics. Retrieving tanks that do not pose a significant risk increases mission cost and increases worker exposure. The objective of the work is to develop an analysis capability that would provide the technical basis for DOE to apply a risk-informed strategy for future tank retrievals and closures.

TECHNOLOGY SOLUTION

This proposed technology development will provide the technical basis and regulatory approach for developing a risk-informed set of retrieval requirements to replace the current volume-based retrieval requirement. This will ensure that mission resources are applied to achieve real risk reduction and avoid retrieval actions that do not have a risk reduction benefit. Specific research objectives include:
- Adapt existing performance assessment models for Waste Management Area {WMA} C and WMA A-AX.
- Evaluate other factors that could be important in determining the risk impacts and benefits of retrieval.
- Develop the regulatory approach and basis for modifying the Tri-Party Agreement's existing volume-based retrieval approach.
- Identify incremental sampling analysis for WMA A-AX tanks that could better inform this retrieval strategy.



TC-99 (ci) in SSTs

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

DFLAW-0008-T: Inadequate DST Space

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An ergonomic cockpit environment to control robots in waste tanks is needed. Develop similar forms of task analysis, metrics, and a computer simulator for the training and operational benefit of tank farm retrieval operators as those used for measuring and modelling robotic surgical skills.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

Computer Simulator to Measure Retrieval Operator Skills

TEDS ID: RTW-43 **Timetable: > 5 Years**

TECHNOLOGY NEED

The development approach for barrier research includes performing market research and preparing a report on the potential barrier technologies in support of single-shell tank retrieval. One Technology identified is to use Direct push technology to inject material to act as a barrier during tank waste retrieval.

TECHNOLOGY SOLUTION

This project will consist of four subtasks:

1. Task analysis and post-action analytics. The team will review copies of logs and videos of completed waste tank retrieval operations to form the raw data for task analysis.
2. Simulator development. The team will modelling robotic surgical skill select an appropriate operating system platform for the simulator.
3. User interface hardware development. During actual tank retrieval, the mobile-arm retrieval system and similar arms are controlled using an industrial control panel consisting of a National Electrical Manufacturers Association-rated enclosure and several joysticks and button controls. The controls will mimic the actual layout, feel, and control actions of the existing retrieval arm console and have identical labels.
4. Operator training study. Four users with no experience will be selected from the University of Washington student body. They will view a set of training slides and then perform a set of exercises in on the simulator. Procedures for the learning curve study will be submitted for prior approval to the University's Human Subjects Institutional Review Board.

Simulator

THREATS AND OPPORTUNITIES

AAXRC-0044-T: Inability to Adequately Staff the Project

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Quantification of Solids in DSTs

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US DEPT OF ENERGY

A combination of sonar and ultrasonic sensors enables 3D profiles of settled solids and in situ measurements of the concentration of suspended solids to determine total volume of undissolved solids. Time-of-flight sonar will provide topography of the settled solids (i.e., bottom profile) based on integrating scans of 2D profiles.

TEDS ID: RTW-44 **Timetable: > 5 Years**

TECHNOLOGY NEED

This technology could reduce the uncertainties and therefore conservatism used by current methods that rely on localized {i.e., point} contract measurements of settled solids levels and sampling to measure suspended solids concentrations.

TECHNOLOGY SOLUTION

The suspended solids concentration changes waste characteristics {e.g., rheology, settling rate} and system performance {e.g., mixing, pipeline transfer}. Solids concentration is an important parameter for estimating slurry rheology and pipeline critical velocity, performing hindered settling calculations, and developing waste acceptance criteria for direct-feed low-activity waste. Furthermore, more accurate undissolved solids accounting enables the tank farm contractor to reliably rebalance tank contents, maximizing the double-shell tank solids inventory and freeing up space. Knowing where the solids are predominantly located is also very important. This information will be critical for modeling chemical addition methods for out-of-specification wastes, and where chemicals should be added so they will not migrate to one side of the tank or the other. The instrumentation allows tracking of interface and suspended solids concentration concurrently as a function of time. Knowledge of time to settle to a desired level and concurrent supernatant concentration provides the ability to initiate transfers when target decant conditions are attained, expediting waste

3D Profiling Sonar & Controller

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Failure in West Area

TFIRR-0045-T: DST Failure in East Area

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

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Barrier Technology

Barrier technology is in the planning stage, requiring development from the ground up. Completion of the research would produce a report that presents deployable barrier options to allow existing retrieval techniques for leaking tanks.

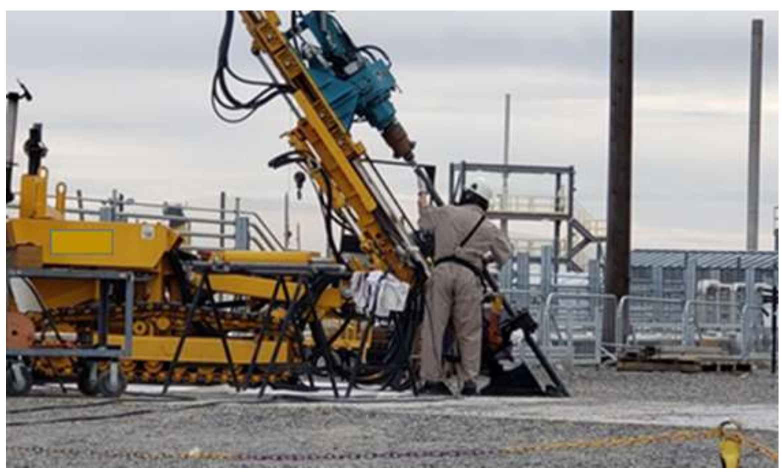
TEDS ID: RTW-52 **Timetable: > 5 Years**

TECHNOLOGY NEED

Hazardous and radioactive tank waste has migrated to the groundwater from surface spills and tank leaks, due to years of waste: storage, transfer and retrieval. There is a potential for future spills, tank leaks and active migration of past and future leaks. Barrier technology would provide a boundary between the waste source and ground water. The barrier would immobilize contamination at the surface, in the tanks or beneath the tanks, preventing waste from reaching the ground water.
Additionally, for leaker-tanks, this technology would allow the use of conventional and new retrieval methods.

TECHNOLOGY SOLUTION

The development approach for barrier research includes performing market research and preparing a report on the potential barrier technologies in support of single-shell tank retrieval. One Technology identified is to use Direct push technology to inject material to act as a barrier during tank waste retrieval.



Direct-Push Rig Angle Drilling

THREATS AND OPPORTUNITIES

TFIRR-0048-T: SST Tank Failure in West Area

TFIRR-0047-T: SST Tank Failure in East Area

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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Improved Configuration Documentation

TEDS ID: RTW-53 **Timetable: ≤ 5 Years**

Three-dimensional flash LIDAR will improve tracking capabilities. The system will map important mission features (e.g., waste, equipment, waste containers).

TECHNOLOGY NEED

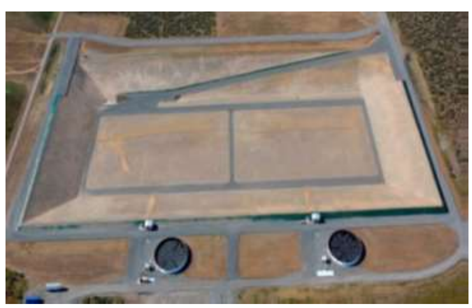
There are many applications with which improved configuration and documentation are required. Three-dimensional flash light detection and ranging {LIDAR} will improve tracking capabilities. The system will map important mission features {e.g., waste, equipment, waste container disposal}. Currently, extensive expenditure of time and material are required to provide this information.

TECHNOLOGY SOLUTION

Retrieval Application – This development process will use various simulated wastes to determine if it can map contours under water and any other limitations would then need to occur.

IDF Application – This development process will need to demonstrate standoff capability to map waste disposal of containers of glass, low- activity waste melters, secondary waste disposal packages, and other items disposed of at the Integrated Disposal Facility {IDF}. The data collected will be required to interface with the Waste Management Information System.

Equipment Application – This demonstration process will need to show accurate configuration of equipment and pit liners to allow remote in- service inspections to satisfy regulatory and code requirements.



Integrated Disposal Facility

Typical Central Pump PIt

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

WRPSC-0011-T: Unexpected Field Conditions Encountered

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Modular Tank Waste Treatment

Modular treatment has been shown to have the capability to increase low-activity waste loading by nearly 30%.

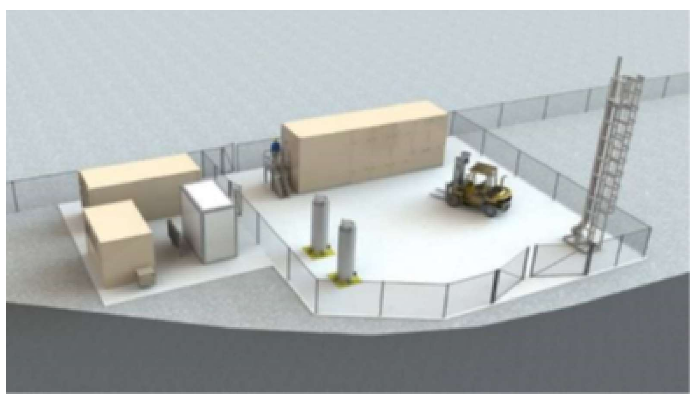
TEDS ID: RTW-54 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Modular treatment has been shown in the subject proposals to have the capability to increase low-activity waste loading by nearly 30%, to treat waste in west area concurrently, which contains more technetium-99 and pumpable liquids and is therefore a higher groundwater risk, and ultimately to provide a back-up plan to current mission strategy and a significant potential to shorten the duration of the current mission.

TECHNOLOGY SOLUTION

Paper study using an engineering cost-benefit analysis approach, possibly integrated with system planning efforts.



Modular Treatment Facility Sketch

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

TFIRR-0011-T: Tank/Infrastructure Failures Prohibit Waste Transfers from DSTs in West Area

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Technology to Support Risk Based Retrieval and Closure

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The proposed technology has the potential to greatly reduce the amount of liquids introduced to double-shell tanks during retrieval by optimizing retrieval endpoints and reducing the number of retrieval operations conducted.

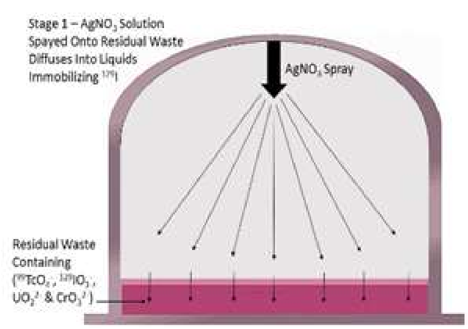
TEDS ID: RTW-56 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

An alternative Hanford tank closure option would be to use effective in-tank chemical stabilization of risk-driving contaminants that supports the use of technically defensible tank retrieval endpoints and demonstrates significant reduction of risk to human health and the environment.

TECHNOLOGY SOLUTION

The proposed technology uses silver nitrate and zero-valent iron to transform technetium, iodine-129, chromium and uranium to insoluble forms that can substantially reduce their leachability from residual waste left in tanks after retrieval. The technology is planned to be implemented by first spraying silver iodide onto the top of the tank waste so it will diffuse into the waste and cause precipitation of any soluble iodine-129 as silver iodide in the entrained liquids of the waste. Next, the waste is planned to be covered with a grout formulation that contains zero-valent iron. This is expected to release +2 valent iron into solution which will diffuse into the entrained liquids in the residual waste. This will cause any dissolved technetium, chromium, and uranium, as well as silver to precipitate. This grout layer can also prevent the system from re-oxidizing by scavenging oxygen from any water that infiltrates into the system.
Permitting implications for this approach will be reviewed.



Application of Getters

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

AAXRC-0004-T: Waste Not as Expected (different than modeled) - Takes Longer or Cannot be Retrieved

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Plutonium/Absorber Mass Ratios Measurement

TEDS ID: RTW-57 **Timetable: > 5 Years**

Technology capable of sampling and/or directly measuring plutonium-to-neutron absorber mass ratios in retrieval waste streams to support criticality safety control strategies for retrieval operations.

TECHNOLOGY NEED

Technology for measuring plutonium-to-neutron absorber mass ratios is needed to support the criticality safety evaluation of operations to dissolve AX-104 sludge with oxalic acid. Another application would be with retrievals from the SY-102, TX-118 and TX-109 tanks that have high inventories of particulate plutonium. The neutron absorbing materials of primary concern are iron, manganese and boron-10, while additional absorbers, such as nickel, silicon, aluminum and sodium are secondary concerns. Ideally, the measurement technology would be able to quantify the plutonium in either the large particle or co-precipitated forms.

TECHNOLOGY SOLUTION

Capability to measure plutonium/absorber mass ratios would establish compliance with evolving interpretations of requirements under the ANSI/ANS 8.14, Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors, criticality safety standard. The standard is being extended, under limited conditions, to be applicable for insoluble neutron absorber materials, such as the iron and manganese credited for ensuring safety of the plutonium in the tank waste. The standard requires verifications of fissile plutonium and absorber inventories during processing.
Current tank waste sampling techniques provide plutonium/absorber inventories under only static tank conditions. As waste is retrieved, some separation of plutonium/absorbers occurs, for example, due to different dissolutions rates under caustic or acidic conditions. Monitoring of dynamic conditions as waste is retrieved can assess effects of plutonium/absorber separation as waste solids dissolve or assess effects of particulate plutonium segregation of lighter absorber materials due to fluid dynamic conditions.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

TFIRR-0046-T: DST Failure in West Area

TFIRR-0045-T: DST Failure in East Area

AAXRC-0070-T: Oxalic Acid Cannot be Added to Tanks

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Tank Crust Sampler

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Caustic Limits report suspects the crust interstitial liquid for certain DSTs could be outside of OSD chemistry limit. Currently there is no known method for sampling tank crust.

TEDS ID: RTW-58 **Timetable: ≤ 5 Years**

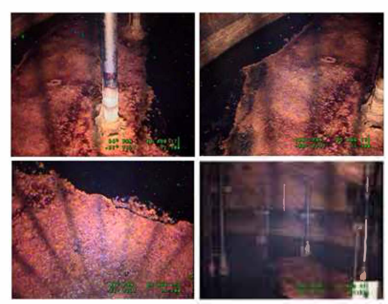
TECHNOLOGY NEED

A sampler that provides a solids core or grab sample of the crust or floating layers in tanks so an evaluation (analysis) of the crust can ascertain tank compliance with OSD-T-151-00007 tank waste chemistry limits.

TECHNOLOGY SOLUTION

Develop a core or grab sampler that can obtain a sample of the crust material. This sampler would be an attachment to a drill string or a suspended grab sampler. The sampler must penetrate the floating material with minimal disturbance and draw the surrounding layer or a portion of the crust into the sample container.

Tank 241-SY-103 as of April 1, 2018



Tank 241-AN-107 as of October 1, 2020

THREATS AND OPPORTUNITIES

TFIRR-0045-T: DST Failure in the East Area

TFIRR-0046-T: DST Failure in the West Area

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

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Retrieval of Sludge from Miscellaneous Underground Storage Tanks

TEDS ID: RTW-59 **Timetable: > 5 Years**

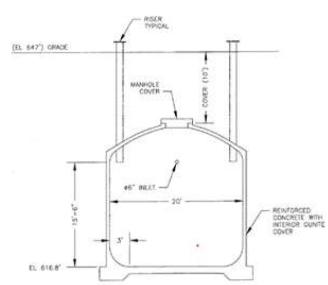
The Hanford Tank Farms has many Miscellaneous Underground Storage Tanks (MUSTs) that can have anywhere from a hundred to a few thousand gallons of sludge that must be retrieved from the tanks prior to closure. New technologies are needed for small tanks or the ability to adapt existing technologies to small tanks. A complication is that many of these tanks are remote and not attached to any piping system, so economical methods to transport the waste to double-shell tanks is also required.

TECHNOLOGY NEED

Waste removal from multiple Miscellaneous Underground Storage Tanks (MUSTs) is required. Specific retrieval methods for small MUSTs (< 5,000 gallons) do not exist except to try and adapt retrieval technologies designed for very large single-shell tanks that cost tens of millions of dollars to deploy. That is not economically practical for tanks with just a couple of hundred gallons of sludge.

TECHNOLOGY SOLUTION

Generate a specification to identify various MUST design attributes to guide retrieval solution options
Submit an Expression of Interest to determine vendor availability
Generate a Statement of Work and initiate a request for procurement (RFP)
Perform vendor selection and initiate contract



Example Miscellaneous Underground Storage Tank

THREATS AND OPPORTUNITIES

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

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C.3 Process Tank Waste

The following are the one-page catalog sheets of the balance of the PTW TEDS.

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Deploy high- to mid- fidelity consolidated Operators Training Simulator (OTS) in TOC for process monitoring and controls. Use OTS as platform for new process development.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

High- to Mid-Fidelity Consolidated Operators Training Simlator

TEDS ID: PTW-26 **Timetable: > 5 Years**

TECHNOLOGY NEED

Need a technology that improves operator proficiencies in running processes such as waste transfers, evaporator runs, exhauster operations, LAW-PS, etc.

TECHNOLOGY SOLUTION

Developing a consolidated high fidelity OTS would provide:
- Increased situational awareness and status control
- Improved response times for upset conditions
- Improved operator environment
- Reduced operating cost
- Encourage excellent and predictable Conduct of Operations
- Reduce unnecessary 'process runs' operations due to training
- Help refine procedures and establishes robust response process.

What's the value of the incident/accident prevented?
- Identify hazards – prevention cheaper than cure
- Control hazards – prevention by preparation
- Perform work – practice makes perfect.

Engineering development may also be achieved by modeling new processes in OTS environment to verify performance and operations. Final process model may then be used as basis for control system development for the new process. OTS platform using J Pro modeling software supports this approach, with established interface to ABB 800xA control system platform. Expansion of existing OTS user base required to take advantage of this capability.

High-Fiedlity OTS

THREATS AND OPPORTUNITIES

WRPSC-0002-T: Resources Not Available When Required

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The current DOE Letter of Direction calls for a phased approach to the startup of River Protection Project facilities and activities. The proposed HLW phased approach builds off of the current DOE strategy by enabling processing HLW solids in the absence of pretreatment.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$5 Million - $10 Million

3 Years - 4 Years

Simplified DFHLW Flowsheet

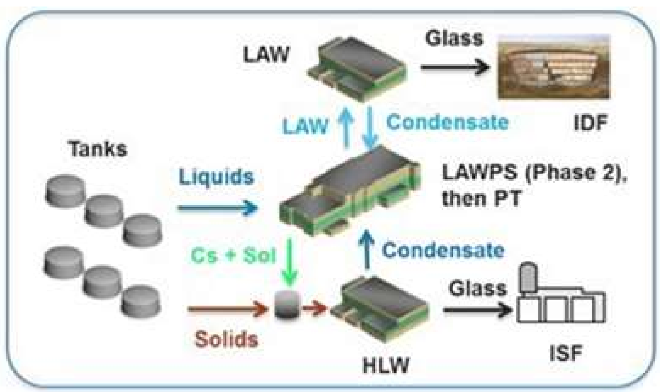
TEDS ID: PTW-40 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The current high-level waste (HLW) flowsheet represents a complex, highly coupled system. The proposed direct-feed HLW (DFHLW) simplified flowsheet would less closely couple the Waste Treatment and Immobilization Plant (WTP) and Low-Activity Waste (LAW), HLW, and Pretreatment (PT) Facilities, enabling more process flexibility, more efficient use of facilities, and earlier processing of HLW. These attributes represent an opportunity to avoid or reduce the amount of glass produced, which in turn reduces the mission length and cost of the HLW glass management.

TECHNOLOGY SOLUTION

Studies and planning are required to adequately define the waste acceptance criteria (WAC), update qualification algorithms, gather data to support the design basis, etc. These studies and planning activities are:
- Develop WAC for the HLW Vitrification Facility
- Develop an appropriate set of simulants for testing the DFHLW flowsheet
- Perform laboratory- and engineering-scale demonstrations
- Develop glass property-composition data and models
- Update glass formulation and qualification algorithms for the revised waste feed
- Perform laboratory-scale demonstration of the DFHLW flowsheet with actual waste samples
- Collect data to support design based on design data needs documented in the detailed engineering study.



Schematic of Proposed Direct Feed HLW

THREATS AND OPPORTUNITIES

DFLAW-0363T-T: WTP LAW Throughput Is Less than Adequate

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High Level Waste Direct Vitrification Condensate Treatment

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Investigate direct feed of HLW to WTP, bypassing the WTP Pretreatment facility and enabling early immobilization of HLW decoupled from other immobilization operations. Operations would include a staged startup and could facilitate continued progress on other RPP mission functions. Stages to be considered are: Stage 1: LAWPS (TSCR), DFLAW, and EMF; Stage 2: add HLW staging and DFHLW Vitrification; and Stage 3: continue sludge treatment in DFHLW flowsheet, identify needs to process liquids from tank farms, and vitrification condensates. This type of technology has been demonstrated and successfully implemented at the Savannah River Site.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

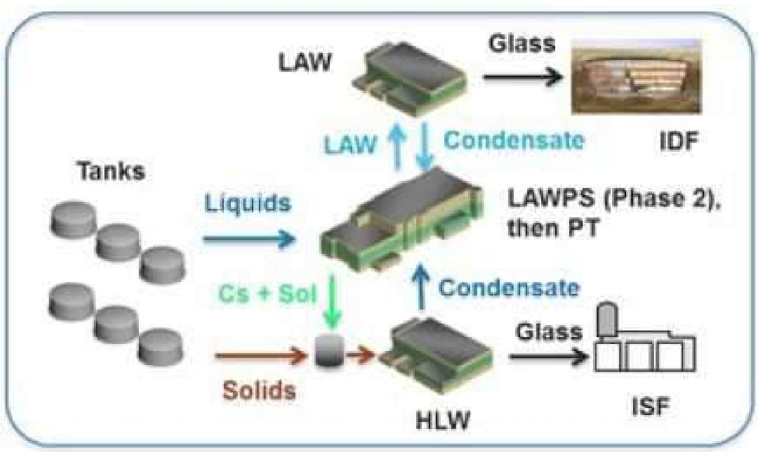
TEDS ID: PTW-42 **Timetable: > 5 Years**

TECHNOLOGY NEED

Current River Protection Project system models (Hanford Tank Waste Operations Simulator and Hanford Waste Treatment and Immobilization Plant [WTP] Dynamic Flowsheet Model [G2]) show the WTP High-Level Waste (HLW) Facility frequently idling while waiting for waste feed delivery and pretreatment (PT) processes. A key objective of the PT process is to remove a large fraction of the non-radioactive chemical components from the tank waste prior to HLW vitrification to reduce the amount of HLW glass produced and ultimately the project cost. Aluminum and chromium are the two primary insoluble chemical components to be removed from the sludge in the PT process, and their removal requires long cycles of leaching and washing.

TECHNOLOGY SOLUTION

A DFHLW process will be evaluated and potentially adopted as an improved flowsheet for managing Hanford tank waste (as shown in Direct Feed HLW Figure 1). To enable such a flowsheet, a relatively large solids receipt and mixing vessel (or vessels) would be required near the HLW Facility to receive sludge transfers from the tank farms and transfer decant solution back. The soluble components of the waste (sodium, sulfur, etc.) can be removed using a settle-and-decant process followed by cesium ion exchange to return cesium to the HLW stream, according to the conceptual flowsheet in Figure 1.



Direct-Feed HLW

THREATS AND OPPORTUNITIES

RPP-0039-T: WTP-HLW Throughput Rate Does not Meet Plan

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The goal of this project is to demonstrate a novel method of selectively sequestering the pertechnetate (Tc (VII)) ion (TcO4-) from radioactive liquid waste by absorbing the water-soluble technetium-99 (99Tc) isotope into porous organic frameworks (POFs) or porous aromatic frameworks (PAFs) with appropriate functional groups.

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

Operations Productivity and Analysis Tools

TEDS ID: PTW-45 **Timetable: > 5 Years**

TECHNOLOGY NEED

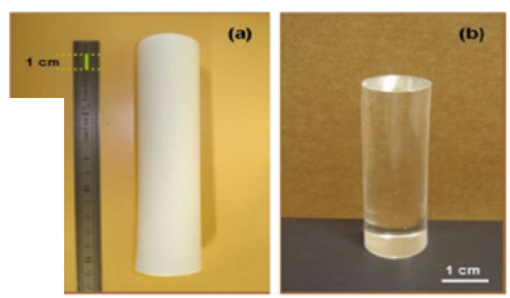
The efficient capture and immobilization of technetium-99 (99Tc) is a grand challenge to performance and risk assessment for the Hanford Site because possible contamination levels in ground water are proportional to ~26,500 Ci of 99Tc currently stored in 177 tanks. Based on the current WTP process flow sheets, almost all (i.e., >90%) 99Tc will be present in the liquid LAW that will be sent to the LAW melter. However, a significant fraction of the 99Tc volatizes at high glass-melting temperatures and is captured in the off-gas treatment system. Development of a highly selective and efficient sorbent for the removal of 99Tc from the liquid secondary waste from LAW melter off-gas condensate is needed. In addition, a viable option is needed to immobilize sorbent loaded with 99Tc into a stable waste form.

TECHNOLOGY SOLUTION

The objective of this project is to develop and demonstrate a new class of porous aromatic frameworks (PAFs) that has a high sorption capacity and selectivity for the TcO4- from liquid waste, and can be subsequently stabilized in a low- cost cementitious waste form. Our goals are as follows:

1. Synthesize aqueous stable PAF with high density of quaternary ammonium salts
2. Evaluate the TcO4- selectivity over other competing anions with batch experiments
3. Develop and evaluate stabilization of the Tc-laden PAF in low-cost cementitious waste form
4. Demonstrate the selectivity and sorption kinetics TcO - from liquid LAW under realistic conditions

Experiments



Experiments

THREATS AND OPPORTUNITIES

DFLAW-0206-T: Secondary Solid Waste Management Less Than Adequate (Tank Farms and WTP)

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Advance CH-TRU Tank Waste Treatment Technologies

HANFORD SITE
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Synergistic retrieval and treatment I packaging technology is needed to lessen the risk of the current wet retrieval and low- temperature, high- vacuum dryer treatment, while minimizing waste needing returned to DSTs. A less complicated drying system coupled with a mechanical treatment protocol is envisioned.

TEDS ID: PTW-46 **Timetable: > 5 Years**

TECHNOLOGY NEED

Preconceptional alternatives report RPP-56063, Transuranic Tank Waste Project Technology Approach Planning, was prepared in February 2014 examining multiple technology approaches to treat contact-handled transuranic (CH-TRU) waste from Expressions of Interest from 14 firms. These were binned in five technology areas: retrieval, treatment, packaging, characterization/storage/shipping, and onsite transportation. This report identified pros and cons of the varied approaches, however, its significant value was in identifying the need for overall integration of technologies after down-selection in CD-1. For purposes of this technology development, it is assumed needed only for retrieval and treatment.

TECHNOLOGY SOLUTION

The existing dryer technology needs re-evaluation in concert with a retrieval strategy. A typical mechanical treatment system is shown below. The Washington River Protection Solutions, LLC (WRPS) Engineering organization has conducted (January-February 2018) a Systems Engineering Evaluation effort to narrow down options and coordinate a synergistic approach to include retrieval, packaging and shipment with the treatment technology, improving upon a 2014 study.

Existing Dryer

Mechanical Treatment System

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$5 Million - $10 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

RPP-0021-T: CH-TRU Waste Treatment Facility Secondary Liquid Waste Does not Meet ETF WAC

RPP-0020-T: CH-TRU Waste Treatment Product Quality is Less Than Adequate

RPP-0019-T: CH-TRU Waste Treatment Throughput Rate is Less Than Adequate

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Prevention of Hydrogen Gas Buildup

To prevent accumulation of hydrogen gas in the LAWPS/TSCR cesium ion exchange columns, the system is planned to be operated under sufficient back pressure to keep hydrogen in solution.

TEDS ID: PTW-48 **Timetable: > 5 Years**

TECHNOLOGY NEED

There has been ongoing discussion around increasing the Low-Activity Waste Pretreatment System (LAWPS) / tank-side cesium removal (TSCR) maximum sodium molarity beyond 6M sodium; however, since hydrogen solubility decreases with increasing sodium molarity and since the existing testing maxed out just over 6M sodium, additional testing will be required at higher sodium molarities to support an increase LAWPS/TSCR sodium molarity waste acceptance. Additionally, further data on hydrogen solubility in waste could provide for further refinement of the current pressure and flow calculations allowing further operational flexibility.

TECHNOLOGY SOLUTION

Would need to be scoped by National Laboratories:
- Identify and develop simulants at molarities above 6M sodium.
- Repeat approach as used in PNL-10785, Solubilities of Gases in Simulated Tank 241-SY-101 Wastes, with these new simulants.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

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Conduct a study to examine the feasibility of removing nitrates from the LAW feed stream prior to vitrification. The study would evaluate the status and applicability of aqueous-phase nitrate destruction processes for pretreatment of Hanford tank waste with the goal of NOX abatement required for the melter off-gas.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

Feasibility of Removing Nitrates from the LAW Feed

TEDS ID: PTW-49 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

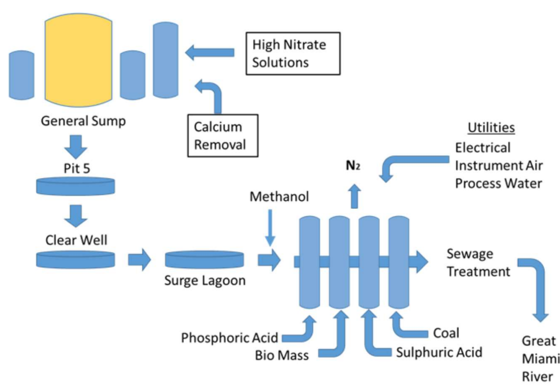
Nitrates in Hanford tank wastes, when processed through the Hanford Tank Waste Treatment and Immobilization Plant (WTP), will generate significant amounts of NOX in the vitrification process off-gas. The NOX must be subsequently reduced to Nitrogen gas through selective catalytic reduction (SCR), which uses anhydrous ammonia as a gaseous reductant. NOX and ammonia represent the top two chemical hazards in the WTP's Low-Activity Waste (LAW) Vitrification Facility. Both chemical hazards could be completely removed from the LAW facility by removing the nitrates in the liquid feed stream before they are fed to the melter, resulting in potentially no active safety functions within the LAW facility.

TECHNOLOGY SOLUTION

This study evaluates the feasibility status and applicability of aqueous-phase nitrate destruction processes with the goal of substantially reducing the extent of NOX abatement required. Specifically:

1. Assess potential techno-economic benefits of the most promising nitrate destruction method(s).
2. Review current state-of-the-art and historical nitrate destruction technologies applied to high nitrate process wastes and tank wastes.
3. Identify one or more promising process options and process configurations.
4. Develop conceptual process flowsheets for the most promising process options and conduct techno-economic assessments.

5, Identify uncertainties, risks, and opportunities associated with the options.



Fernald FMPC Biodenitrification Process

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

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Address the strict particle size limit by either increasing the limit indicated in ICD-19 by replacing the WTP sampling system or separating particle sizes with a hydrocyclone.

High Level Waste Solids Segregation

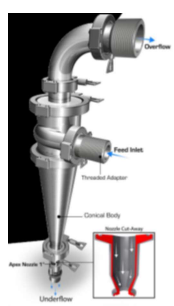
TEDS ID: PTW-50 **Timetable: > 5 Years**

TECHNOLOGY NEED

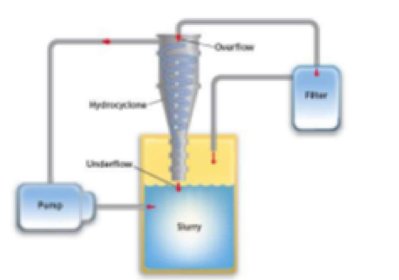
Simple and reliable technologies are needed to ensure DFHLW feed meets the 310 µ particle size-density criteria listed in ICD-19, Interface Control Document for Waste Feed as driven by the ASX samplers used by WTP. Larger particles would cause damage to the septums in the sample bottles.

TECHNOLOGY SOLUTION

The strict particle size limit is the result of a limitation of the sampling system set in place by WTP. An effective means to lift the restriction may be to install a replacement sampling system that is capable of capturing larger particle sizes. ICD-19 would also need to be changed accordingly to adjust for a larger size limit. Alternatively, a new process unit will be required to treat the waste to remove larger particles. Hydrocyclones are the most widely used unit operation to size-classify particles in a wet grinding circuit. Hydrocyclones separate particles from a slurry over a range of particle sizes (nominally 5 to 500 µ). Separation is accomplished by feeding a slurry tangentially into the cone shaped hydrocyclone. The rotating flow creates centrifugal forces within the stream and accelerates the settling rate of dense/large particles. The denser/large particles settle to the bottom of the cone and exit in the underflow. The less dense/smaller particles exiting the top of the cone in the overflow. The underflow is cycled back into the grinding circuit and the overflow is moved forward for processing.



Hydrocyclone Example



Hydrocyclone Example

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

3 Years - 4 Years

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

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Nitrite-Hydroxide Solubility to Determine Aluminum Solubility in DFLAW

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US DEPT OF ENERGY

To determine if aluminum will precipitate and foul the direct-feed low-activity waste process, we need solubility interaction factors between all major constituents in the liquid phase with both the aluminate ion and nitrite ion. We are currently missing the nitrite-hydroxide interaction factor.

TEDS ID: PTW-51 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

Aluminum precipitation has fouled ion-exchange columns treating Hanford waste (Barton et al. 1986; PNNL-21109). The Savannah River Site has also experienced process problems with aluminum precipitation from supernatants (SRNL-STI-2013-00700). This plugging has occurred because aluminum has precipitated where it was not anticipated. The Flowsheet Maturation Plan (RPP-PLAN-58003) has proposed that a better aluminum solubility model be developed so that aluminum precipitation can be better anticipated. The plan suggests that new solubility data be generated that is specifically target at determining solubility model parameters. The plan indicates that one of the most important solubility model parameters that is currently unavailable is the nitrite-hydroxide liquid phase interaction parameter and indicates that this can be determined by measuring the solubility of sodium nitrite in solutions containing sodium hydroxide over a range of temperatures and hydroxide concentrations. Aluminum precipitation has fouled ion-exchange columns treating Hanford waste (Barton et al. 1986; PNNL-21109). The Savannah River Site has also experienced process problems with aluminum precipitation from supernatants (SRNL-STI-2013-00700).

TECHNOLOGY SOLUTION

The nitrite-hydroxide interaction coefficient can be determined from either solubility data or water activity in mixtures of aqueous solutions of nitrite and hydroxide. It is assumed that this would measure solubility rather than water activity because solubility is conceptually simpler. However, if a laboratory can measure water activity instead, that would work just as well for model parameterization, as long as they can ensure that it is a measure of water activity at equilibrium. To get a statistically significant interaction parameter over the temperature interval of 20 to 85 °C, three to four data points over the whole solubility range recorded for at least four different temperatures are required.

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

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Establish real-time monitoring process control for DFLAW, including demonstrated plant instrumentation to reduce the need for extensive process control samples. Sampling and analysis will be limited to periodic verification and confirmation.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

3 Years - 4 Years

Real-Time Process Control for DFLAW

TEDS ID: PTW-54 **Timetable: ≤ 5 Years**

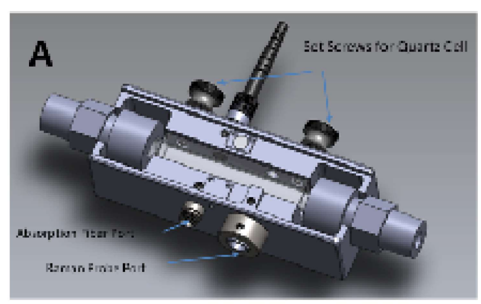
TECHNOLOGY NEED

Process control for direct-feed low-activity waste (DFLAW) operation relies on process sample collection and analysis for composition information. The process cycle times for many vessels in the Low-Activity Waste Vitrification Facility and Effluent Management Facility is very short, requiring an increased number of samples to support operations. Additionally, the sampling and analysis duration coupled with the increased number of samples will challenge operations. This burden on the laboratories and impact on the process cycle time has the potential to impact operational throughput.

TECHNOLOGY SOLUTION

Applying a combination of automated material balances with selected real-time in-line monitoring with laser-induced breakdown spectroscopy (LIBS) or Raman probes will reduce the number of samples required and avoid process delays due to time-consuming sample analysis. Proven analytical modeling techniques can be adopted for use with the unique Hanford Site tank treatment matrices and analytes and for application to radioactive operations. The goal of the technology development is to limit sampling and analysis to periodic verification and confirmatory needs with the as low as reasonably achievable exposure goal of significantly reducing sample collection and time-consuming conventional analysis while maintaining compositional uncertainties within acceptable levels. Any implementation of real-time process control instrumentation requires an understanding of uncertainties and their impact on modeling (e.g., glass models).

LIBS Probe



Raman Probe

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

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Treated Waste Concentration/Evaporation

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A modular concentration or evaporator system that can be utilized with treated Low Activity Waste (LAW) generated by the Tank Side Cesium Removal System (TSCR). The system development and deployment would utilize a commercially available Mechanical Vapor Recompression (MRV) evaporator. This MRV evaporator could be used to concentrate low sodium molarity LAW wastes produced in West area to ensure feed would meet waste acceptance criteria.

Technology Maturation Level

Modify Existing Technology

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

TEDS ID: PTW-56 **Timetable: > 5 Years**

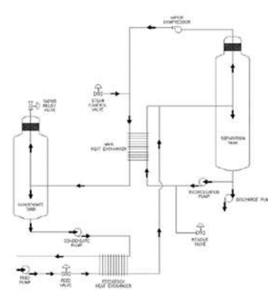
TECHNOLOGY NEED

Treated LAW concentration capability is needed to support processing of low sodium concentration wastes. Processing of the salt cake wastes in West area will likely result in low sodium molarity LAW feed. Instead of attempting to blend this feed with higher sodium molarity feeds a commercially available packaged Mechanical Vapor Recompression (MRV) evaporator can be used to bring the feed into the required WAC range. Key activities would include testing on a pilot scale system followed by development of a full-scale system.

TECHNOLOGY SOLUTION

he proposed MVR process uses a commercially available packaged evaporator. The MRV process uses a compressor to increase the pressure of the vapor drawn from above the waste surface generating an increase in temperature which is then used to heat the waste medium being concentrated. This in turn creates more vapor that is recompressed to continue the cycle. The cooled vapor is then pulled off as condensate which can be used to support waste retrievals. This process allows for concentration while operating near atmospheric pressure and limited energy input for operation.

Commercial Package MVR



MVR Principle

THREATS AND OPPORTUNITIES

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In-Tank Solids Suspension

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In-tank mixing capability will be critical for obtaining representative samples of direct-feed high-level waste. Computational Fluid Dynamics modeling will be utilized to aid in DST mixer pump optimization. This CFD effort will significantly decrease the amount of small-scale mixing test that will be required to designed a DFHLW feed preparation system.

TEDS ID: PTW-57 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

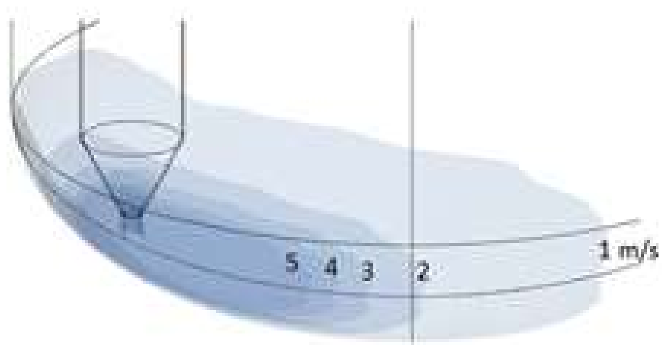
In the event that a DFHLW scenario is pursued, one DFHLW flowsheet requirement will be the ability to homogeneously suspend solids in existing DSTs so that:

▪ representative samples of the slurry can be taken,
▪ solids retention and accumulation at the bottom of the tank is minimized, and
▪ the slurry can be effectively transferred to the WTP HLW Vitrification Facility.

Previous solids mixing work (e.g., Small-Scale Tank Mixing Demonstration, AZ-101 Pump Test) did not demonstrate the solids suspension to the level needed for DFHLW operations. Without this development, DFHLW may not feed the HLW Vitrification facility at slurry concentrations sufficient to keep the HLW melters continuously operating.

TECHNOLOGY SOLUTION

As a first step in the development of in-tank solids suspension for DFHLW, CFD modeling will be utilized to define the optimum DST mixer pump configuration to maximize the potential to meet the solids suspension requirements needed for sampling and transport. This configuration may include the number of mixer pumps, the location of mixer pumps, the rotational speed of the mixer pumps, the number of nozzles per mixer pump, the nozzle diameter, the nozzle velocity, minimum and maximum slurry height, transfer pump placement, and transfer pump inlet height. CFD results would then be used as input to small-scale mixing demonstrations. The CFD modeling effort will reduce the effort needed in the small-scale mixing demonstrations and will result in a DFHLW process design that has less risk of working sub-optimally or being over-designed.



CFD Model Example

THREATS AND OPPORTUNITIES

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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Solids Settling Rate Determination/Solids Washing Techniques

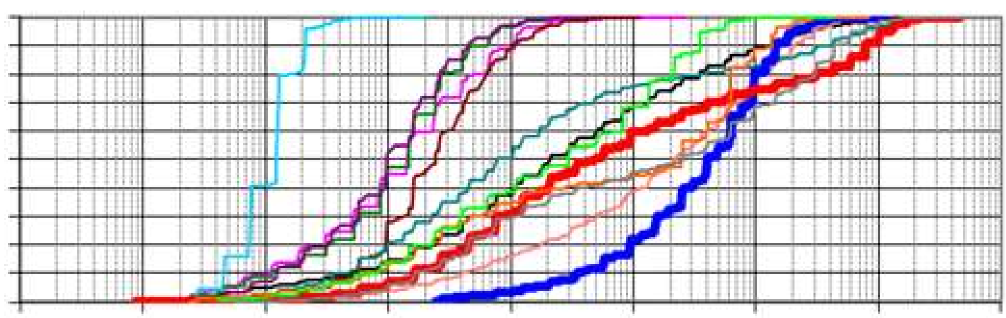
TEDS ID: PTW-58 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The current knowledge of settling rates for Tank Farm waste solids is poor. Because Tank Farm transfer operation are infrequent, the assumption that setting would be nearly complete prior to the next operation has been acceptable. However, if a Tank Farm pre-treatment system for DFHLW operations is to be designed to include solids settling, more information is needed. The setting rate of different solids in current tank waste as well as in low ionic strength was solutions at various was temperatures is needed. This information is needed to determine the size or number of washing tanks needed to maintain the required processing rate.

TECHNOLOGY SOLUTION

The initial project will involve running washing and settling experiments on actual tank sludge solids waste in hot cells to determine the setting rate of the solids as well as the effect of washing and mixing on the settling rate and the particle size. Once solids settling rates and the effects of washing and mixing are accurately determined additional engineering analysis and technology review will be required to determine an appropriate solids washing tank system configuration to maximum the processing rate.



Cumulative Volume Percent vs. Settling Velocity

THREATS AND OPPORTUNITIES

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

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C.4 Manage Waste

The following are the one-page catalog sheets of the balance of the MW TEDS.

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Remotely Operated or Automated ETF Internal Tank Cleaning Device

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A means is needed to clean the ETF process tanks interior walls and roofs without manned entry.

TEDS ID: MW-10 **Timetable: > 5 Years**

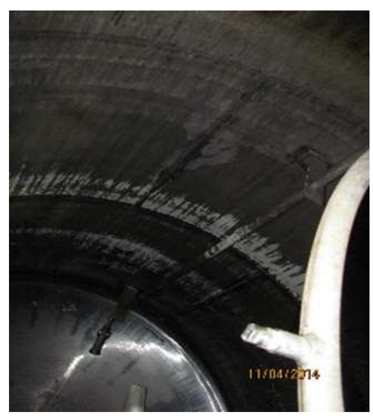
TECHNOLOGY NEED

The ETF process tanks build up scale that cannot be removed by soaking or recirculating with chemicals. This provides a mechanism for accelerated corrosion and inhibits Resource Conservation and Recovery ACT (RCRA) required tank integrity inspections. The ETF secondary waste process tanks are considered at risk. Adequate tank cleaning will allow for a full assessment of the tanks to support replacement for or replacement delay based ongoing assessment. A functional cleaning technology will mitigate operational impacts and risks of implementing more aggressive manual cleaning techniques including manned tank entries. Cleaning reduces the risk of tank failure by helping to control pitting.

TECHNOLOGY SOLUTION

ETF needs a method of cleaning scale from process tank interiors that cannot be cleaned by soaking or recirculating with suitable chemicals. The cleaning device should be deployable through a 30-in. tank top manway in congested area and operated remotely or automatically. Manned entries into the tank are not an acceptable option. The tanks have bottom drains and range up to 15 ft wide by 20 ft high.

Secondary Waste Process Tank



Secondary Process Tank Interior

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

ETFOP-0043-T: ETF Secondary Waste Receiving Tank Failure

Contractor: Rose Russell
Phone: (509) 376-0451
Email: rose_m_russell@rl.gov

DOE-ORP: Richard Valle
Phone: (509) 376-7256
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HANFORD SITE
US DEPT OF ENERGY

Upgrade Solid Waste Information and Tracking System

TEDS ID: MW-12 **Timetable: > 5 Years**

Technology development for software upgrades to accommodate identification and tracking of Waste Treatment and Immobilization Plant (WTP) solid secondary waste that can be disposed at the Integrated Disposal Facility (IDF).

TECHNOLOGY NEED

Regulations require waste to be tracked and managed. The Solid Waste Information and Tracking System {SWITS) is currently used by all contractors to track and manage waste. SWITS needs to be upgraded to handle the waste generated by the Waste Treatment and Immobilization Plant {WTP).

TECHNOLOGY SOLUTION

SWITS is used site wide and the tracking software for managing waste containers. If it is to be used at WTP it will have to be upgraded to include WTP specific items. To do this will require the participation of SWITS maintenance contractor. Also, the Central Plateau contractor {CP) will operate the Integrated Disposal Facility {IDF). The CP will need to decide what program to use for track waste into and out of the IDF. If they decide not to use SWITS, then this is not an issue.

SW/TS Database Menu

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

Contractor: **Douglas Swenson**
Phone: (509) 373-9279
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DOE-ORP: **Christopher Kemp**
Phone: (590) 373-0649
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Transportation Requirements for New Equipment Disposal

HANFORD SITE
US DEPT OF ENERGY

TEDS ID: MW-13 **Timetable: > 5 Years**

Proposed technology is unknown. t will depend on what waste or samples Waste Treatment and /mmobilization Plant plans to ship during its lifetime. A waste shipping container is needed. /f the plant plans to ship highly radioactive, very large, or heavy items it will need to have a package designed and built.

TECHNOLOGY NEED

Ensure that transportation requirements are addressed in the development of new equipment. Any equipment developed {i.e., Waste Treatment and Immobilization Plant melters and bubblers) will at some point, need to be replaced and disposed of. An appropriate waste package is needed to enable transportation to disposal. Sampling methods need to be considered. Waste sampling methods will confirm proper waste packaging and sample transportation per applicable regulations.

TECHNOLOGY SOLUTION

Identify unique equipment or samples that need to be taken and ensure a transportation package exists for that item. Examples are tank waste samples larger than 1 liter or high-dose high-curie large equipment.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

DFLAW-0357-T: Spent/Failed LAW Melter disposal capability not available when needed

Contractor: David Swanberg
Phone: (509) 376-0710
Email: david_j_swanberg@rl.gov

DOE-ORP: Glyn Trenchard
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HANFORD SITE
US DEPT OF ENERGY

At-Tank Technetium and Iodine Removal and Disposition

TEDS ID: MW-15 **Timetable: ≤ 5 Years**

Fabricate and test ion exchange resins tuned to selectively retain Technetium and Iodine using a monolithic column configuration for deployment at-tank or in-tank.

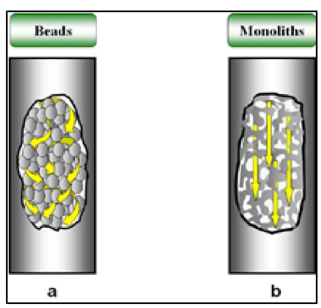
TECHNOLOGY NEED

Tc-99 and I-129 are long-lived, highly mobile radionuclides that are volatile at glass melting temperatures. They will likely be a component in the WTP off-gas treatment system secondary wastes unless removed prior to entering the glass melter. Removing Tc-99 and I-129 from off-gas secondary wastes would remove potentially problem contaminants from the IDF waste inventory and protect the Columbia River.

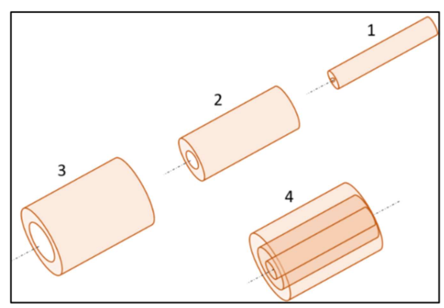
TECHNOLOGY SOLUTION

Work is needed to develop, mature, and deploy technology for "tunable" Tc- and I-selective IX resins. Monolithic columns create a "single large particle" that fills the column entirely as a continuous skeleton with a series of connected pores that allow no void. The monolithic column develops a network of channels in the continuous phase of a porous material that shows high axial permeability, a large internal pore surface area and less back pressure than that of conventional packed columns.

The Monolithic Column figure depicts three preparation steps. Different parameters can be applied to control porous properties. These include polymerization temperature, the choice of pore-forming solvent or porogen, the type and amount of crosslinking monomers and polymerization time.



Conventional (a) and Monolithic (b) IX Column "cut-away" showing resins



Monolithic Column

Technology Maturation Level

Laboratory Testing

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

2 Years - 3 Years

THREATS AND OPPORTUNITIES

DFLAW-0232-T: WTP Radioactive Dangerous Liquid Effluent Composition LTA

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C.5 Dispose Tank Waste

The following are the one-page catalog sheets of the balance of the DTW TEDS.

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US DEPT OF ENERGY

Advance the technology to ship large quantities of radioactive and mixed liquid waste offsite for treatment and/or disposal.

Advance Liquid Waste Transportation Capability

TEDS ID: DTW-06 **Timetable: > 5 Years**

TECHNOLOGY NEED

This effort advances the capability to ship large-quantity radioactive and mixed liquid waste off-site for treatment and/or disposal. The shipment of small-quantity liquid waste and all solid waste offsite is very mature, except for spent melters, which are addressed in the Manage Waste function. There is currently no baseline or lifecycle planning associated with shipment of large quantity liquid waste off the Hanford site. This technology development would only be needed should a strategic planning scenario for offsite treatment/disposal of tank waste in liquid form be implemented. Implementation of a revised offsite shipment strategy would require the design and fabrication of new shipping casks to meet mature transportation criteria (i.e., criteria from NRC, DOT, and DOE). The fabrication and certification of a new shipping container would not require DOE technology development, however, the interface systems from the new shipping container may need development. Also, the certification testing of the new container for DOE usage may require National Laboratory review/approval, if not the actual testing.

TECHNOLOGY SOLUTION

Establish criteria to procure new shipping container to meet regulatory requirements for large-quantity shipment (no technology development) Procure new certified shipping container (no technology development except for potential National Laboratory involvement in the certification testing) Develop technology for interface/transportation of the new shipping container (technology development involved in this effort)

Transporter

THREATS AND OPPORTUNITIES

DFLAW-0357-T: Spent/Failed LAW Melter Disposal Capability Not Available When Needed

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

Contractor: **Buddy Cunningham**
Phone: (509) 373-6018
Email: buddy_m_cunningham@rl.gov

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Evaluation of Commercial Treatment and Offsite Disposal

HANFORD SITE
US DEPT OF ENERGY

Test Bed Initiative 2 is being conducted to demonstrate the programmatic efficacy of off-site commercial treatment and out-of-state disposal for treated mixed low-level waste from Hanford tanks.

Technology Maturation Level

Prototype

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$5 Million - $10 Million

2 Years - 3 Years

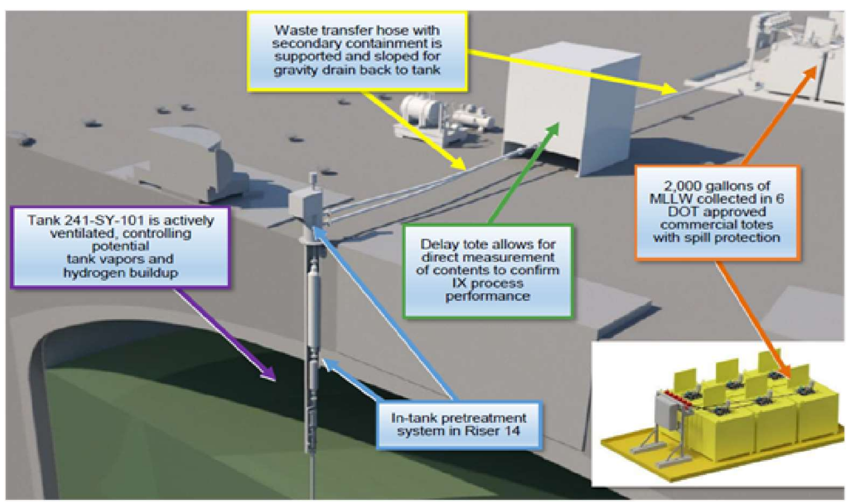
TEDS ID: DTW-10 **Timetable: ≤ 5 Years**

TECHNOLOGY NEED

The Department of Energy (DOE) is evaluating potential benefits to enhance Hanford's tank waste mission to reduce risk, cost, and inform a needed supplemental treatment decision for Hanford's tank waste mission and to gain regulatory, stakeholder, and public acceptance to provide a pathway for commercial treatment and disposal. In support of this evaluation, the DOE is conducting a 2,000-gallon Test Bed Initiative 2 (TBI 2) to demonstrate the feasibility of retrieval and treatment of waste at the Hanford Site in Washington State.

TECHNOLOGY SOLUTION

The design was completed for the TBI system in 2019, which includes a pump, filter, ion exchange column, control system, transfer lines, and totes to receive the treated waste. WRPS is supporting the initiative by performing the installation, operation and shipment of the treated waste to the immobilization facility. Performance validation testing has been completed through a Factory Acceptance Test by the equipment fabricator. The waste pre-treated by the TBI system will be sampled and shipped offsite for immobilization and disposal.



Tank Farm TB2 Waste Retrieval

THREATS AND OPPORTUNITIES

DFLAW-0362-T: WTP LAW is not ready to receive treated tank waste feed when DFLAW support projects are ready to start operations

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

Contractor: Jordan Follet
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DOE-ORP: Richard Valle
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Email: richard_j_valle@orp.doe.gov

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Integrated Disposal Facility Risk Budget Tool Monitoring

Technology is needed that would accurately verify waste inventory (radionuclide inventory) and physical characteristics of containers (external dose, heat, etc.) for containers coming into the IDF.

TEDS ID: DTW-11 **Timetable: > 5 Years**

TECHNOLOGY NEED

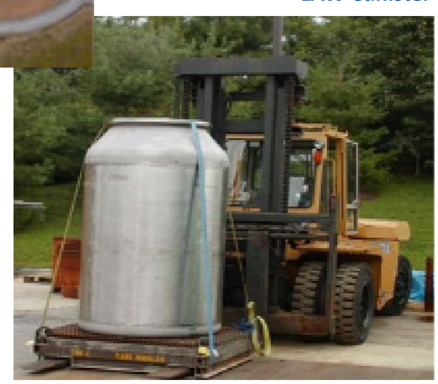
Software development is needed to allow the waste generator to accurately input radionuclide and chemical inventory data directly into the Waste Management Information System (WMIS) and have the software verify the data input is within the limits of the waste profile. This need applies to both immobilized low-activity waste (LAW) glass and secondary waste streams.

TECHNOLOGY SOLUTION

Provide a software to more accurately track radionuclide, chemical inventory, and physical properties of the containers to efficiently manage the disposal of LAW in the Integrated Disposal Facility (IDF). This technology solution must interface with WMIS to more effectively manage the IDF waste acceptance process.

Integrated Disposal Facility

LAW Canister



THREATS AND OPPORTUNITIES

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

No

Rough Order of Magnitude Cost & Duration?

$1 Million - $5 Million

0 Years - 2 Years

Contractor: **Tim Wintle**
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Evaluation of Natural Analogues to Support Tailored Grout

HANFORD SITE
US DEPT OF ENERGY

Grout can be tailored to enhance durability when amended with phases intended to sequester specific troublesome radionuclides such as technetium and I-129. Many of those phases are analogues to natural minerals which are inherently stable. This activity would evaluate the natural analogue data to show that tailored grouts could be more durable than glass for key risk-driving radionuclides.

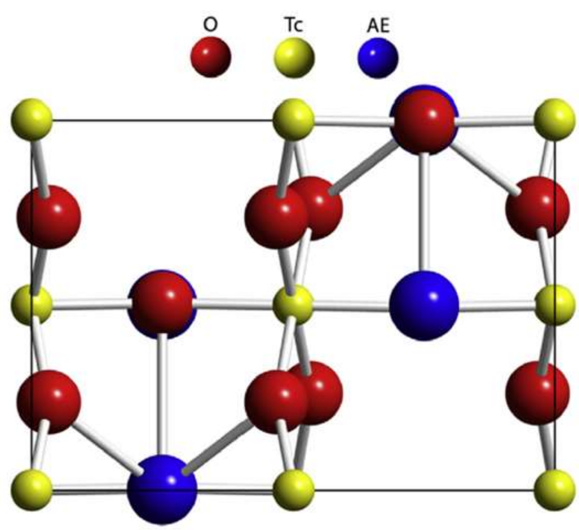
TEDS ID: DTW-12 **Timetable: > 5 Years**

TECHNOLOGY NEED

Develop and qualify a tailored grout waste form for supplemental immobilization of Hanford low-activity waste (LAW). This waste form is needed to sequester specific troublesome radionuclides such as technetium and iodine-129.

TECHNOLOGY SOLUTION

This technology development phase will be a literature review on the geological stability of various solid phases in arid environments. This should show that pyrochlore, goethite, hematite and potentially magnetite are geologically stable. The initial focus would be on phases that sequester technetium and iodine. Follow-on technology development phases will include tailored grout formulation testing.



Model of Tc incorporation in SrTcO3

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

Contractor: **Jacob Reynolds**
Phone: (509) 373-5999
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Email: Erik.Nelson@rl.doe.gov

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Long-term durability of cementitious materials is uncertain and should be valuated through examination of ancient manmade and natural materials.

Long Term Durability of Cementitious Waste Forms

TEDS ID: DTW-13 **Timetable: > 5 Years**

TECHNOLOGY NEED

Long-term durability of cementitious waste forms is an uncertainty that affects the regulatory approval of these materials for low activity waste. Fresh waste forms may meet disposal requirements, however regulators often are skeptical that cementitious waste forms will remain intact rather than crumble, thereby increasing the diffusive transport area. Increases in transport area directly increases the rate that waste products are released from the solid waste form.

TECHNOLOGY SOLUTION

Collect and analyze information on natural and anthropogenic ancient cement materials to quantify the stability of the underlying crystalline structures and macro properties.

Example of Ancient Concrete from the Roman Empire

Pozzolan (volcanic ash) deposits in Southern California

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

2 Years - 3 Years

Contractor: **Rodney Skeen**
Phone: (509) 372-0501
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Complex-Wide Database for Cementitious Waste Form Properties

HANFORD SITE
US DEPT OF ENERGY

A central electronic repository for experimental results, technology reports, and lessons learned associated with the development and application of cementitious waste forms for radioactive wastes is needed to facilitate the use of the most up-to-date information in decision making. The repository should be made accessible across the DOE complex through a web-based interface that facilitates locating, searching, and retrieving information.

TEDS ID: DTW-14 **Timetable: > 5 Years**

TECHNOLOGY NEED

Multiple DOE laboratories and contractors are developing and testing cementitious formulations for solidifying a variety of liquid and solid wastes. This information is not well organized or distributed and the best information is often not incorporated into decision documents such as Performance Assessments. A central repository for this information along with a web accessible database interface is needed to facilitate access.

TECHNOLOGY SOLUTION

This need can be met by working with both the experts developing and testing cementitious waste forms, and those who are developing and maintaining Performance Assessments to:

1. Identify the data needs and presentation formats that is most advantageous to the data users.
2. Determine what information and associated metadata is considered a high priority by the data users.
3. Collect, annotate, catalog, and store experimental results, technical reports, and lessons learned associated with developing and disposing of cementitious waste forms.
4. Code and promulgate a web interface within the DOE complex to make the information available.

Technology Maturation Level

Research and Concept

National Laboratory Involvment?

Yes

Rough Order of Magnitude Cost & Duration?

$0 - $1 Million

0 Years - 2 Years

THREATS AND OPPORTUNITIES

DFLAW-0363-T: WTP LAW Throughput is Less Than Adequate

Contractor:	**Rodney Skeen**	**DOE-ORP:**	**Erik Nelson**
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APPENDIX D TECHNOLOGY ELEMENT DESCRIPTION SUMMARY AND CATALOG SHEET FORMS

D.1 INTRODUCTION

The following forms represent the TEDS sheets (Figure D-1 and Figure D-2) and the single and double page catalog sheets for technology needs being pursued (Figure D-3 and Figure D-4), and technology needs not currently being pursued (Figure D-5).

As discussed in Section 4.1, the TEDS sheets are populated by the technology requester ("prepared by") who is knowledgeable regarding the need and possibly the proposed solution. The requester is not obligated to propose a solution to the stated technology need but is welcome to submit possible solutions or concepts through the TEDS process. The requester also provides cost/funding and schedule information as appropriate. The TEDS sheet is then used to generate the catalog sheet which further summarizes the technology development process being proposed and/or a status of ongoing progress. The blank catalog sheets (i.e., Figure D-3 through Figure D-5) are to indicate the information cross-walk between the TEDS sheet and the catalog sheet.

Figure D-1. TEDS Form, Page 1.

Technology Element Description Summary

input for the Technology Roadmap

The Technology Roadmap (RPP-PLAN-43988) is scoped to address the technology needs of the Office of River Protection (ORP) and assist with mission planning. To facilitate development of the document, the Chief Technology Office is coordinating with ORP and its contractors to identify and prioritize technology needs. This Technology Element Description Summary worksheet is a tool for documenting that information.

Identification #:	FA-##	**Prepared By:**	First Name Last Name
Revision Number:	0, 1, 2, ... etc.	**Contractor POC:**	First Name Last Name
Submittal Date:	Click here to enter	**DOE-ORP POC:**	First Name Last Name

1. Technology Title

A few words to describe the technology

2. Technology Summary

Provide a FEW sentences summarizing the need and proposed technology.

3. Priority Ranking

Click to select

High: technology needed within 1-4 yrs, or ORP-identified strategic need
Medium: technology needed within 5-10 yrs
Low: technology needed >10 yrs

4. Baseline Status

Click to select

5. Functional Area

(check the box that best describes the technology functional area)

Manage Tank Waste (MTW)	Retrieve Tank Waste (RTW)	Process Tank Waste (PTW)	Manage Waste (MW)	Dispose Tank Waste (DTW)
☐Tank Farm Ops	☐Retrievals	☐LAWPS	☐LERF/ETF	☐IDF
☐Vapor Programs	☐DST Transfers	☐EMF	☐Secondary Solid Waste	☐IHLW Interim Storage
☐Infrastructure Upgrades	☐Cross-Site Transfers	☐WTP LAW Vitrification	☐Secondary Liquid Waste	☐WIPP
☐242-A Evaporator	☐DST Upgrades	☐WTP HLW Vitrification	☐Tc Management	☐Off-Site Disposition
☐222-S Laboratory	☐Feed Preparation	☐WTP Pretreatment	☐Cs Management	☐Off-Site Transport
☐Sampling & Transport	☐Tank Closure	☐TWCS	☐Melter Disposal	☐other: specify
☐other: specify	☐other: specify	☐CH-TRU	☐other: specify	
		☐other: specify (e.g., DFLAW, DFHLW, flowsheets, etc.)		

6. Grand Challenge

Was this technology submitted as a Grand Challenge? Click for yes/no

If yes, what year? Click for year Title? Title of Grand Challenge

7. Technology Impact and Risk Identification

(choose one)

☐ A) Risk Mitigation
☐ B) Opportunity
☐ C) Mission Need

If you answered A or B on the left, fill out this section:

Does this technology address a risk identified in a Risk Register? (if unsure, contact your Risk SME) Click for yes/no

Risk ID number(s): Risk ID
Handling action(s)?: Click for yes/no

Additional space here to describe the risk, opportunity, or mission need. If there are known handling actions associated with the Risk IDs, please list and describe them here.

8. Technology Need

Why is this technology needed? Provide a description of the mission need, requirement, or issue that is driving the proposed technology solution. Point to how the technology will fill the need or gap, mitigate risk, and how it relates to the overall TOC mission. Identify the date when this technology is needed. Identify TPA milestones or impacted projects, if applicable.

Rev. 1 12/14/2017

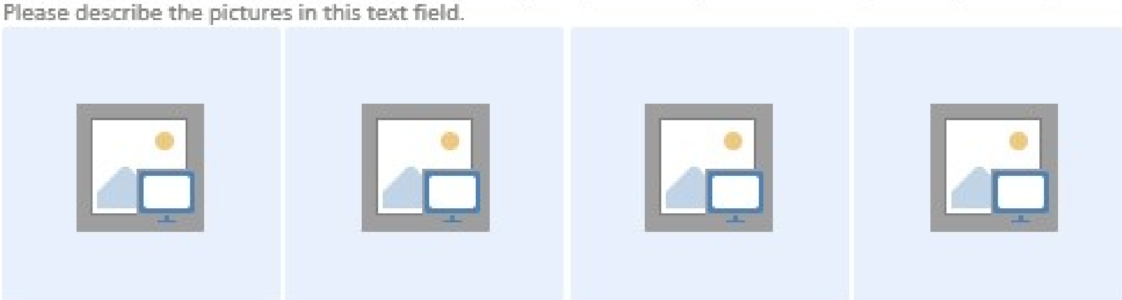
Figure D-2. TEDS Form, Page 2

Technology Element Description Summary

input for the Technology Roadmap

9. Technology Solution

Provide a short summary of the proposed solution, what it will do, and how it will be developed (e.g., Task 1, Task 2, Task 3…). If you can, please elaborate on the technical details (if you answered "planned" in Box 4, we expect you to). Pictures, sketches, or conceptual models are always helpful. Insert pictures below by clicking on the picture icon. Please describe the pictures in this text field.



10. Technology Maturation Level

Choose maturation level

Will national laboratory involvement be needed? Click for yes/no

11. Cost and Schedule Summary

If you answered "needed" in Box 4, fill out this section.

ROM overall project cost:

☐ <$1 million ☐ $1-$5 million ☐ $5-10 million ☐ >$10 million

Overall project duration (time to complete project):

☐ 0-2 years ☐ 2-3 years ☐ 3-4 years ☐ 4+ years

If you answered "planned" in Box 4, fill out this section.

Schedule (for additional task description rows, Right Click >> "Insert schedulesum After"):

Project or Activity	Year 1				Year 2				Year 3				Year 4				Totals
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Enter task description	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	$
Funding in thousands (000s)	$				$				$				$				$

WBS number: Add WBS number here.

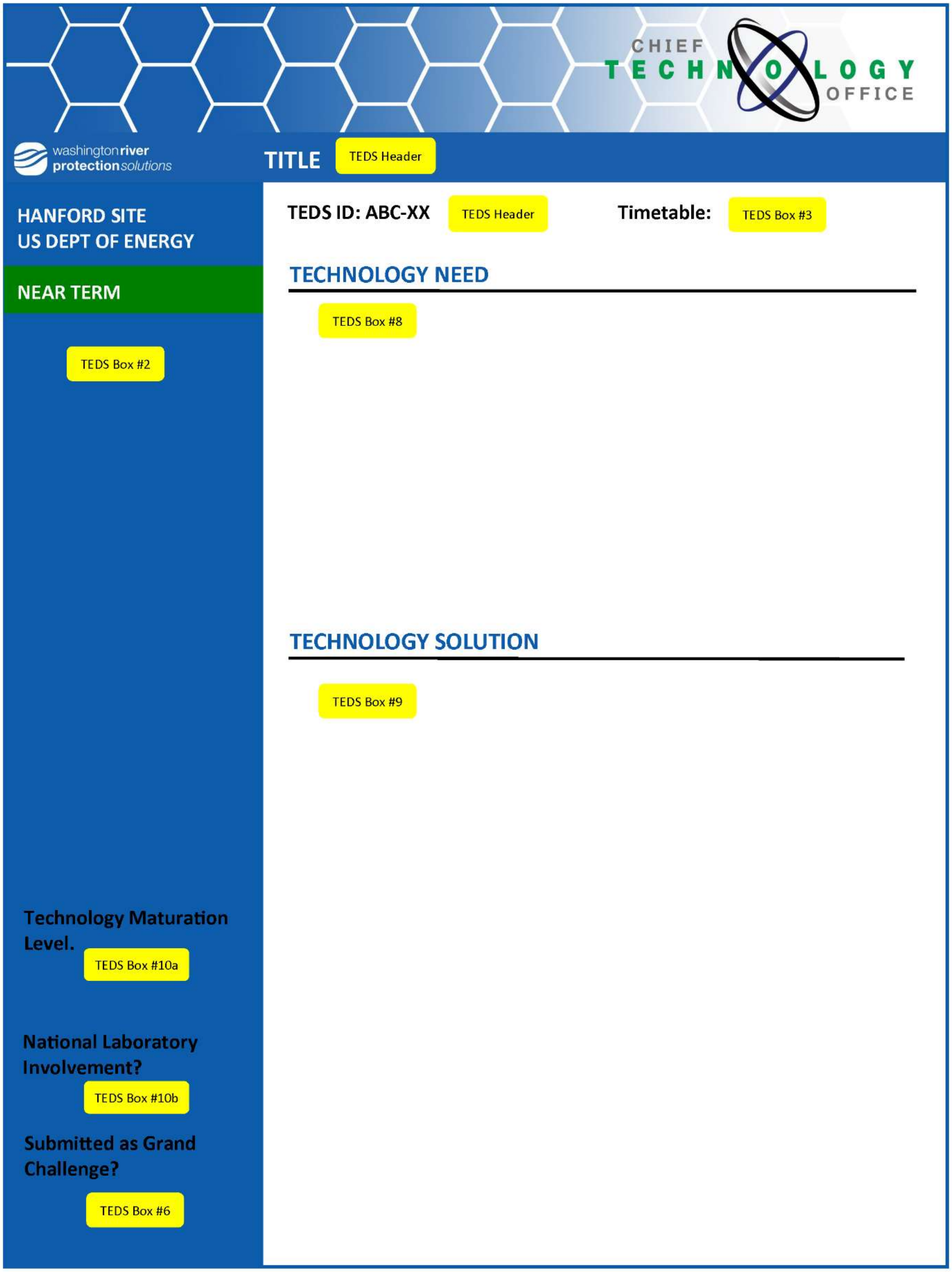
12. References (applicable supporting documentation, e.g. Reports, SOW, Functions and Requirements)

List document references. If the work is currently funded, provide the Scope of Work number.

13. Comments

Add additional comments here.

Figure D-3. Double Page Catalog Sheet, Page 1.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TITLE TEDS Header

HANFORD SITE
US DEPT OF ENERGY

NEAR TERM

TEDS Box #2

TEDS ID: ABC-XX TEDS Header

Timetable: TEDS Box #3

TECHNOLOGY NEED

TEDS Box #8

TECHNOLOGY SOLUTION

TEDS Box #9

Technology Maturation Level. TEDS Box #10a

National Laboratory Involvement? TEDS Box #10b

Submitted as Grand Challenge? TEDS Box #6

RPP-PLAN-43988, Rev. 6

Figure D-4. Double Page Catalog Sheet, Page 2.

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TITLE TEDS Header

TEDS Header **TEDS ID: ABC-XX Continued**

ADDITIONAL TECHNICAL INFORMATION

TEDS Box #9

PRELIMINARY ESTIMATE AND SCHEDULE SUMMARY

TEDS Box #11

RISKS AND OPPORTUNITIES

TEDS Box #7

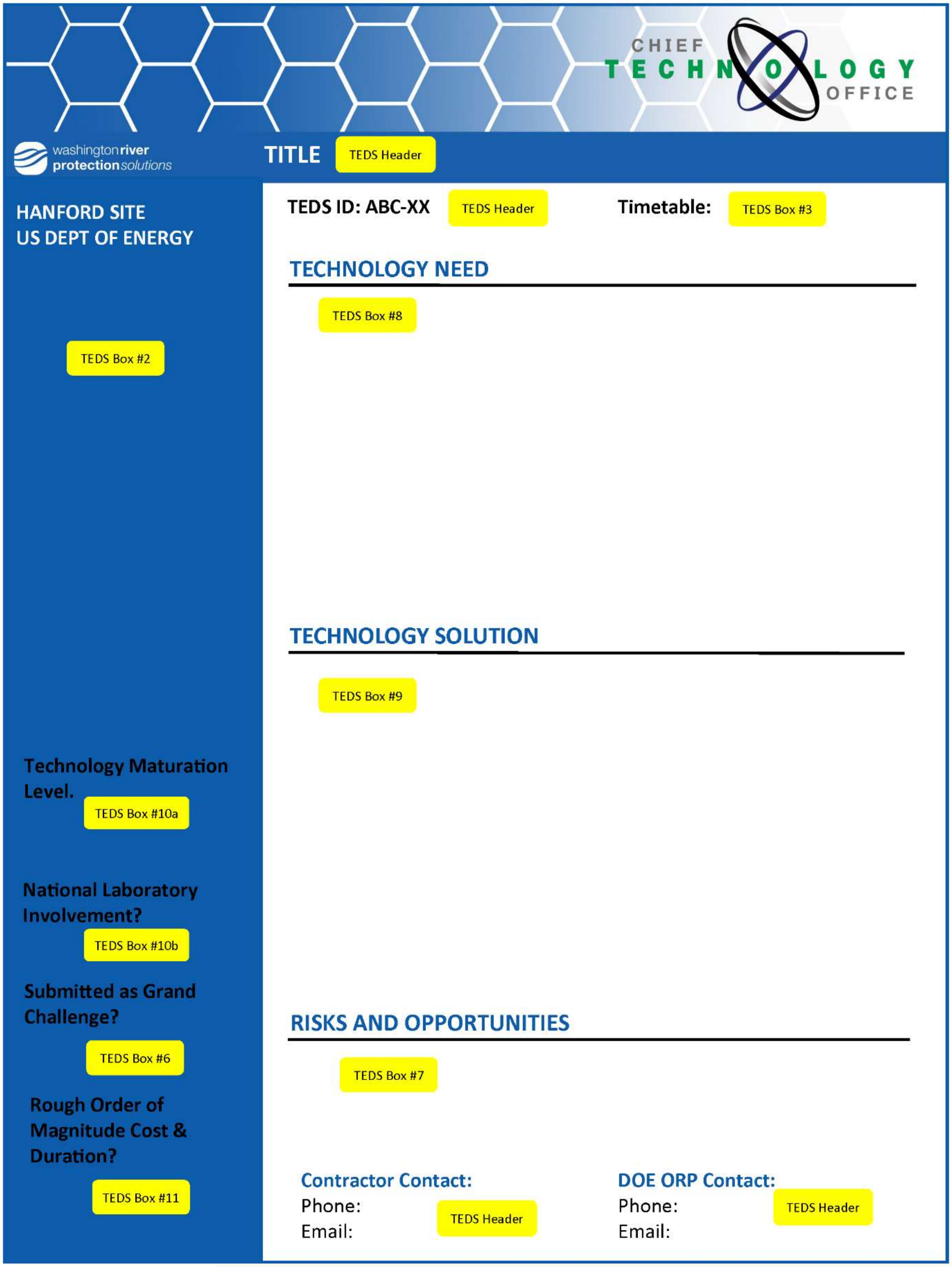
MEASUREABLE ORGANIZATIONAL VALUE

TEDS Box #13

Contractor Contact: TEDS Header
Phone:
Email:

DOE ORP Contact: TEDS Header
Phone:
Email:

Figure D-5. Catalog Sheet for Future Technologies.



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TITLE TEDS Header

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TEDS Box #2

TEDS ID: ABC-XX TEDS Header

Timetable: TEDS Box #3

TECHNOLOGY NEED

TEDS Box #8

TECHNOLOGY SOLUTION

TEDS Box #9

Technology Maturation Level. TEDS Box #10a

National Laboratory Involvement? TEDS Box #10b

Submitted as Grand Challenge? TEDS Box #6

Rough Order of Magnitude Cost & Duration? TEDS Box #11

RISKS AND OPPORTUNITIES

TEDS Box #7

Contractor Contact:
Phone: TEDS Header
Email:

DOE ORP Contact:
Phone: TEDS Header
Email:

APPENDIX E TECHNOLOGY DEVELOPMENT ACHIEVEMENTS AND TEDS RETIREMENT SUMMARY

E1.0 Introduction

This appendix highlights some of the significant accomplishments the CTO has achieved over the past few years. As work has progressed, several TEDS sheets have been "retired." There can be several reasons for retirement, as follows:

- The need has been met
- No longer needed – mission need changed
- No longer needed – risk no longer exists
- Reclassified as non-technology development
- Combined with another TEDS
- Deemed unsuccessful, no longer pursued
- Risk Accepted

This appendix documents technology development achievements and retired technologies.

E2.0 Recent Technology Development Achievements

These achievements have helped to reduce the Hanford life-cycle cost by providing the most effective technology equipment, materials, and processes. The achievements were reached using research, testing, and analyses. The achievements were enabled by having strong relationships with the National Laboratories, Academia, DOE ORP, stakeholders, and technical service providers (suppliers).

TEDS identification has been provided for identified technologies. A couple technology developments have occurred prior to the TEDS development process and have been noted accordingly.

Tertiary Leak Detection and Foundation Robotic Inspection – Complete (MTW-73) Retired

WRPS worked with Eddyfi Technologies to develop a robotic inspection system to enable inspections of the double-shell tank foundation space within the AW and AN tank farm design configuration. This inspection system was designed, built, and tested to deploy through leak detection pit access, travel vertically down near the bottom of that leak detection system riser, and insert an inspection camera system into the foundation to sump interconnection drain line. This system is designed to provide a visual inspection of the drain slot within the tank foundation, underneath the secondary liner and to investigate evidence of secondary liner corrosion from environment.

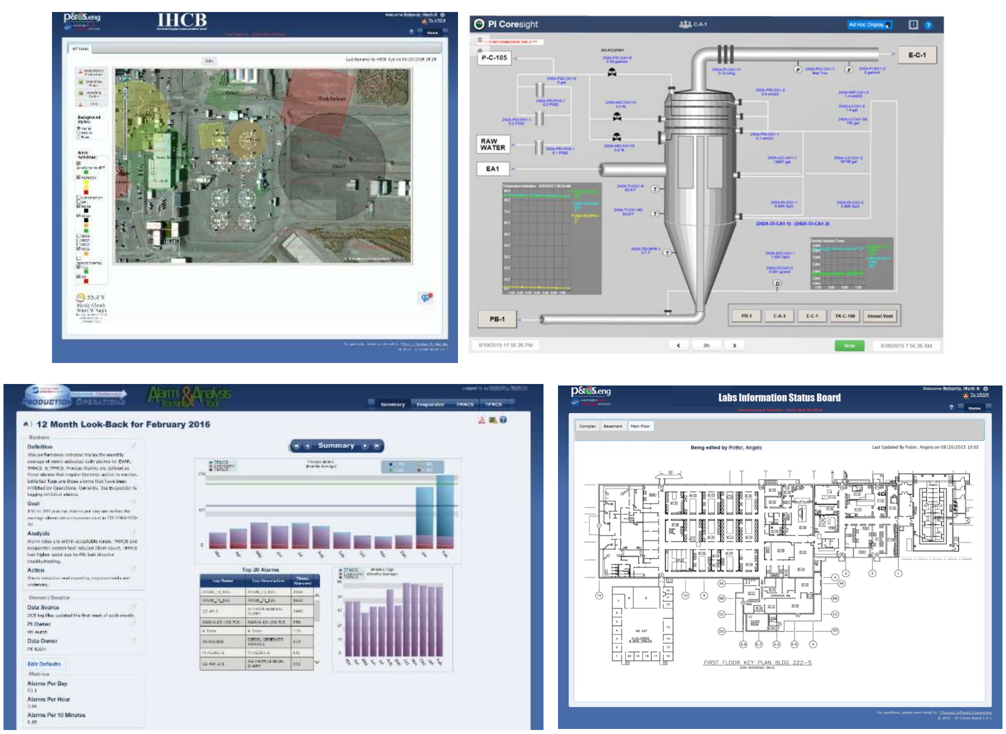
High- to Med-Fidelity Consolidated Operators Training Simulator – In Work (PTW-26) – On Going

Operator Training Simulators are now available for each main facility within the Tank Operations Contract. The Effluent Treatment Facility monitoring and control system simulator was developed as part of the monitoring and control System upgrade and is being fully utilized by Operations and Engineering to review and validate procedure changes and facility modifications. The 242-A monitoring and control system simulator has been operational for a number of years and is actively being utilized. The Tank Farm monitoring and control system has also been developed and turned over to operations and is currently being updated to match the current production system configurations. While there is still a need for a consolidated operator training simulator, the technology is developed and actively utilized.

TSCR Simulator utilized during Readiness Assessment

Operations Productivity and Analysis Tools - Complete (PTW-28) – Retired

A common set of productivity and analysis tools have been developed to transform data from variety of sources into reliable, decision-ready information. The work involved development of key infrastructure and data historians, and then leveraging that infrastructure to overlay web-based applications to deliver the information. Around 50 applications have been developed to assist Operations and Engineering and have transition from development into the operations and maintenance lifecycle phase. This Technology Element Description can be closed out as implemented.



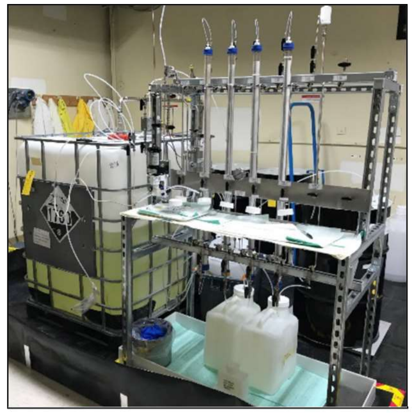
Top-Bottom Left-Right: Industrial Hygiene Communications Board Kiosk; PI Core Sight Display; Alarm & Analysis Tracking Tool; Laboratory Information Status Board

Tank-Side Cesium Removal (TSCR) - Complete (PTW-52) - Retired

Essential to provide waste feed of the overall DFLAW program mission. The TSCR key objective is to remove undissolved solids and radioactive cesium from DST supernatants and feed the treated waste directly to the WTP LAW Vitrification Facility for immobilization. This project is the replacement for the LAWPS project. All development to support design, fabrication, testing, and commissioning have been accomplished. Work continues on operational support.

Technology development testing demonstrated successful:

- Full height ion exchange (IX) column performance
- IX testing with Hanford Site waste
- Gas generation rate for key conditions
- Equilibrium contacts for key conditions
- IX media drying rates
- Filtration testing with simulant
- Filtration testing with Hanford waste



TSCR Testing Demonstration

Continuous Emissions Monitor Smart Sampler – Complete (MTW-24) – On Going

The Continuous Emissions Monitor (CEM) Smart Sampler system was developed to provide a high fidelity, reliable stack monitor for use on Hanford actively ventilated tanks. The system can also provide area and tank headspace-sampling capability. The CEM unit includes real-time multi-gas analysis utilizing an ultra-violet – differential optical absorption spectrometer to detect a handful of important vapor Chemical Of Potential Concern (COPC) constituents and a flame ionization detector (FID) that determines total volatile organic compounds. In addition, the unit includes a gas chromatography-FID (GC-FID) to allow detection of a large number of COPCs every hour and includes an autonomous programmable whole-air grab sampling capability utilizing Summa cans and sorbent tubes. That is, more comprehensive than the existing stack monitoring units. In February 2020, a factory acceptance test was completed.

Technology development accomplishments include:

- Completion of system design
- Equipment procured
- Equipment tested

CEM Smart Sampler

Fugitive Emissions – In Work (MTW-24) – On Going

The fugitive emissions (FE) detection technology purpose is the development of an FE identification and characterization program for improved worker safety. The mission benefits for this technology include:

- Potentially decrease the need for high level of personal protection equipment (PPE), thereby improving productivity in tank farms
- Educate workforce on nature of odors detected outside tank farms
- Enhance safety culture awareness for workforce

AreaRAE

Technology development accomplishments include:

- Procured and installed equipment for odor sampling and analysis
- Conducted investigations around tank farms to establish database of odors
  to quantify chemical levels to reduce/eliminate hazardous conditions for the workforce
- Developed tools that establish method and process for vapor trail with source characterization

ToxiRAE Pro

The Fugitive Emissions Detection project is implemented with some ongoing IH activities.

NUCON Thermal Oxidation System – In work (MTW-24) – On Going

NUCON International, Inc. has successfully developed a thermal oxidation system (TOS) based on an internal combustion engine. Tests have been underway since early 2017 to determine the destruction removal efficiencies (DREs) for Hanford COPCs using this technology. Progress to date show majority of COPCs destroyed. The mission benefits of this technology are:

- Minimize on-going ops through better emissions management
- Improves worker environment vapor control
- Enhances safety culture awareness for the workforce

NUCON Thermal Oxidation System

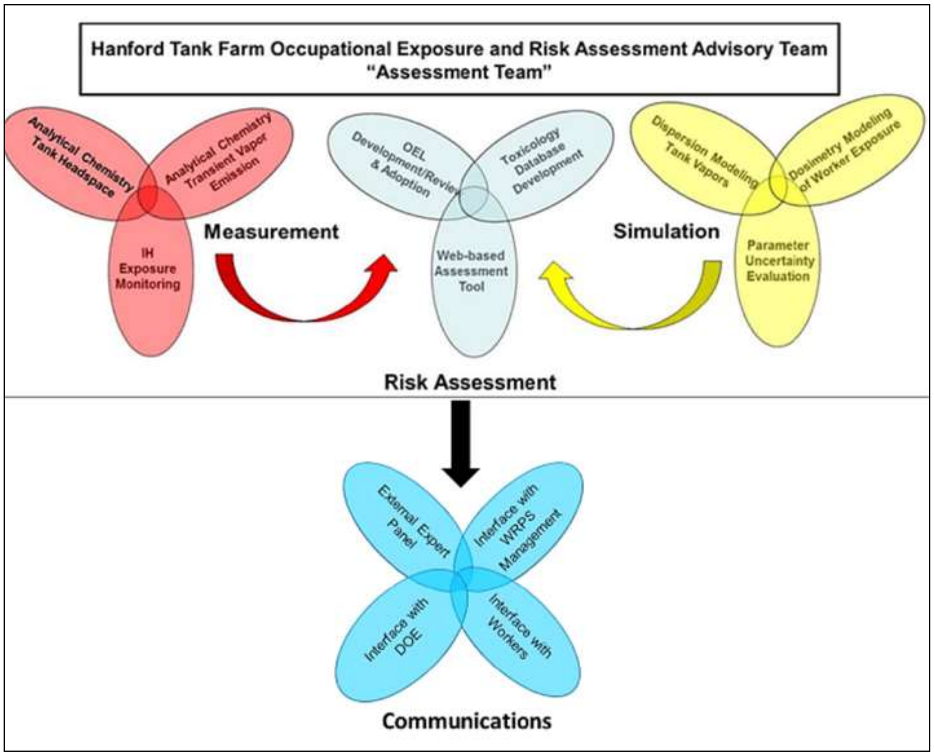
Technology development accomplishments include:

- Conducted successful proof-of-concept tests in May
- Conducted successful offsite engineering-scale tests
- Completed design of NUCON TOS at tank BY-108
- Conducted successful ANSI N13.1 Testing

Health Process Plan (HPP) - Complete (MTW-24) – On Going

Health Process Plan is a peer-reviewed process for assessing potential health risks associated with worker exposures to chemical emissions from the Hanford tank farms. When fully implemented, the recommendations from the plan will facilitate future risk-management decisions that are grounded in state-of-art measurement, simulation and assessment practices. These decisions will enhance the overall work environment and Hanford mission. Technology development accomplishments include:

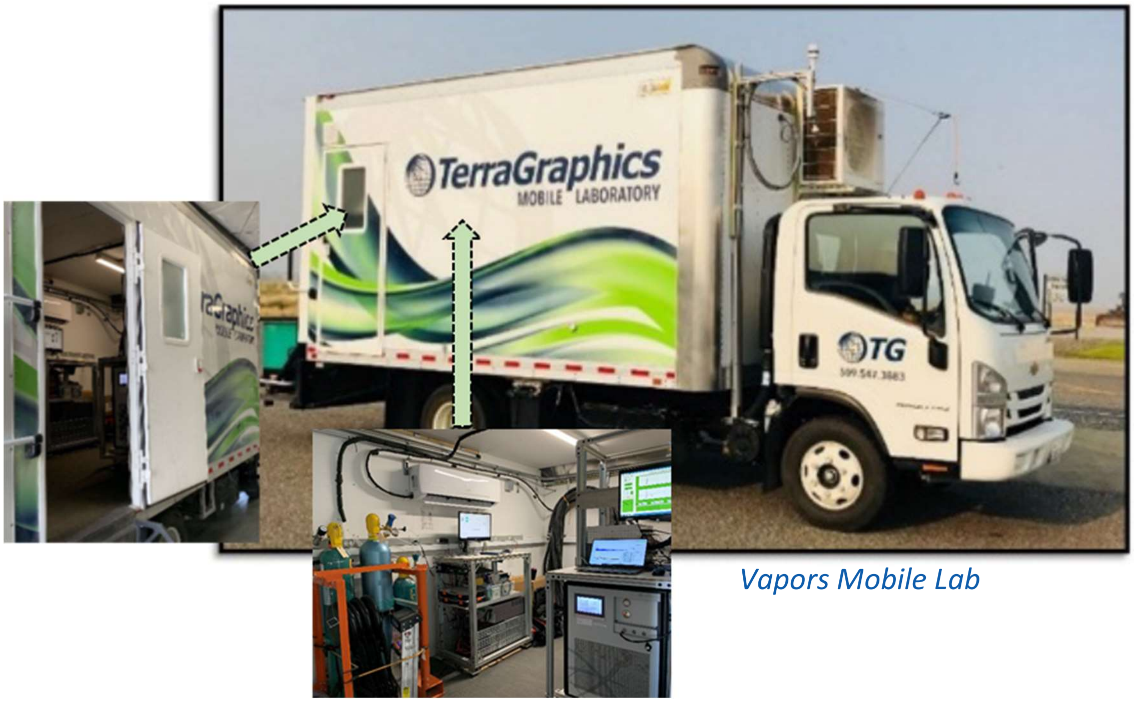
- Established a process to consider updates to occupational exposure limits that includes internal and external peer review.
- Reviewed current toxicological information and updated the basis for Hanford Occupational Exposure Limits (OELs).
- An assessment Team has been established for the integration of all information about tank farm emissions, exposure guidelines, and critical data that enable risk-management decisions and stakeholder communications.



HPP Health Risk Assessment Process

Vapors Mobile Lab – Complete (MTW-24) – On Going

The mobile laboratory van, operated by TerraGraphics, is an analytical laboratory that provides air and vapor analysis around tank farm perimeters. The mobile laboratory monitoring augments Industrial Hygiene sampling and monitoring in the tank farms and monitors outside of the farms for vapor sources.



Vapors Mobile Lab

The mobile laboratory supported a variety of projects including:

- Background and leading indicator studies
- FE
- Waste-distributing activities
- General area sampling
- Real-time quantitative analysis by mass

Impacts include:

- Locates and characterizes the sources of known and fugitive vapor emissions across the Hanford Site
- Provides ultra trace gas analysis for compounds of concern
- Provides data to help minimize operational delays
- Enhances work environment and Hanford mission

The mobile lab fulfilled all project goals and has been subsequently discontinued.

Tank Farm Boundary

Tank Farm Waste-Disturbing Activities

Deep Sludge Gas Removal Event (DSGRE) Investigation (Prior to TEDS Process) - Complete

In 2014, C Tank Farm SST retrievals operations were on track to remove SST sludge waste and transfer/consolidated in DSTs to a depth greater than previously experienced at Hanford. Previous operational understanding indicated that flammable gases generated in the sludge would escape through a connected pathway of cracks in the sludge. However, some theoretical studies indicated that there was a limit to the depth of the connected pathways, that could result in the gas removal event capturing pockets of gas.

Deep Sludge Test Column

The objective of the DSGRE investigation was to evaluate this theory and resolve the Unreviewed Safety Question (USQ). The test column was fabricated and tested under representative sludge conditions and multiple test scenarios. The results indicated that flammable gases did escape through inherent pathways in the sludge and that the tank farms operations were within the existing safety basis. The test results provided the basis for continuation of tank farm transfers and allowed the furthering of tank closure supporting the Hanford cleanup mission.

Technology development accomplishments include:

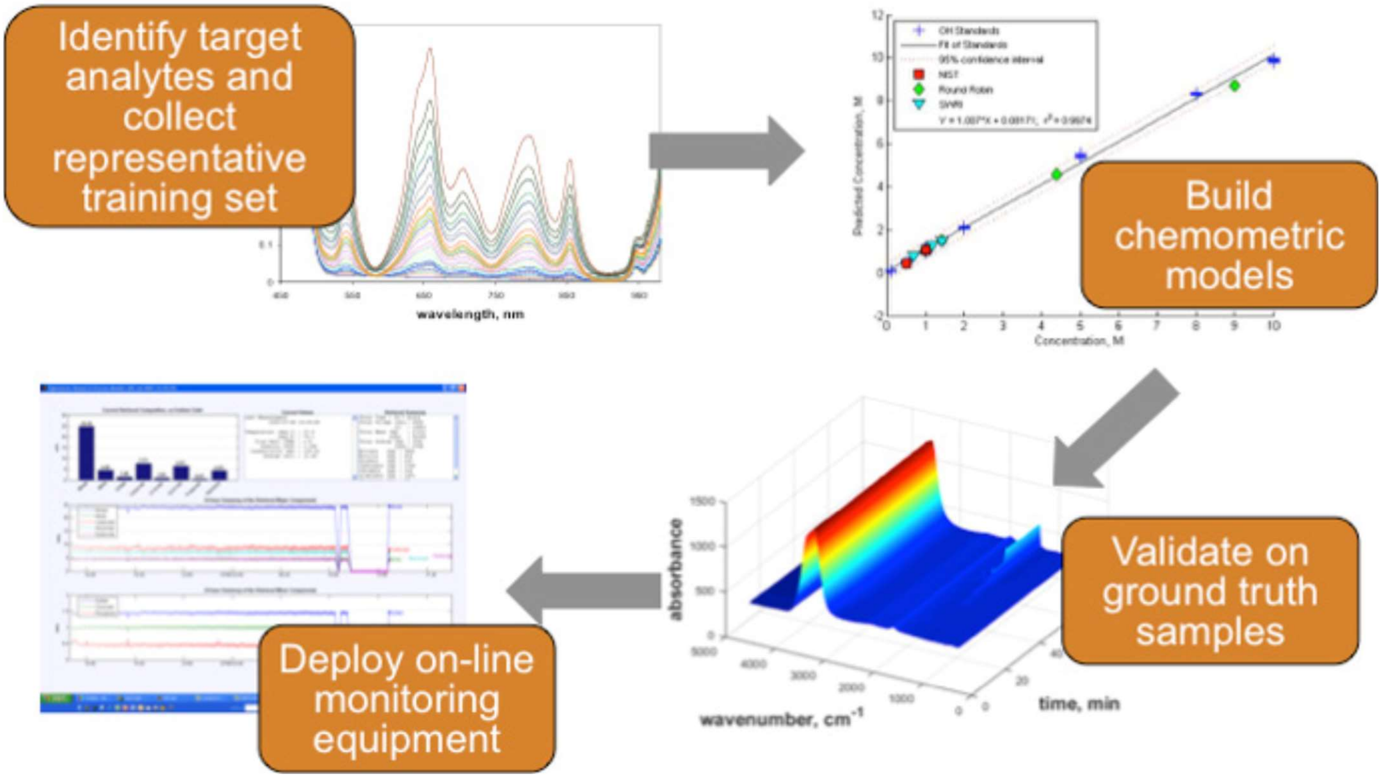
- Provided technical basis to enable completion of sludge retrievals from C Tank Farm SSTs
- Completed design and construction of the tall column test system and completed testing to demonstrate the gas retention does not increase with increased waste sludge depth
- Evaluated a theory in literature of a depth where gas channels collapse, block gas transport, and cause gas instability relative to Hanford specific conditions

Online Monitoring (Raman Spectroscopy) – In Work (MTW-76) – On Going

A well-established, commercial technology that has been developed to support an online sampling system to continuously measure tank waste constituents on a per batch basis. Raman spectroscopy is an optical technique used to identify Raman active molecules in a sample. The process starts with laser excitation. The resulting scattered light is then measured, and the light measurements are formed into a spectrum. Technology development is complete and ready for deployment.

Technology development accomplishments include:

- Shorten sample analysis turnaround time
- Increase frequency of sampling
- Decrease costs
- Maintain as low as reasonably achievable (ALARA) exposure
- Allow for more analysis of non-homogenous waste
- Reduction in the need for human interaction with waste samples



Online Monitoring (Raman Spectroscopy) Development & Deployment Process

Isolok Sampler (Prior to TEDS Process) - Complete

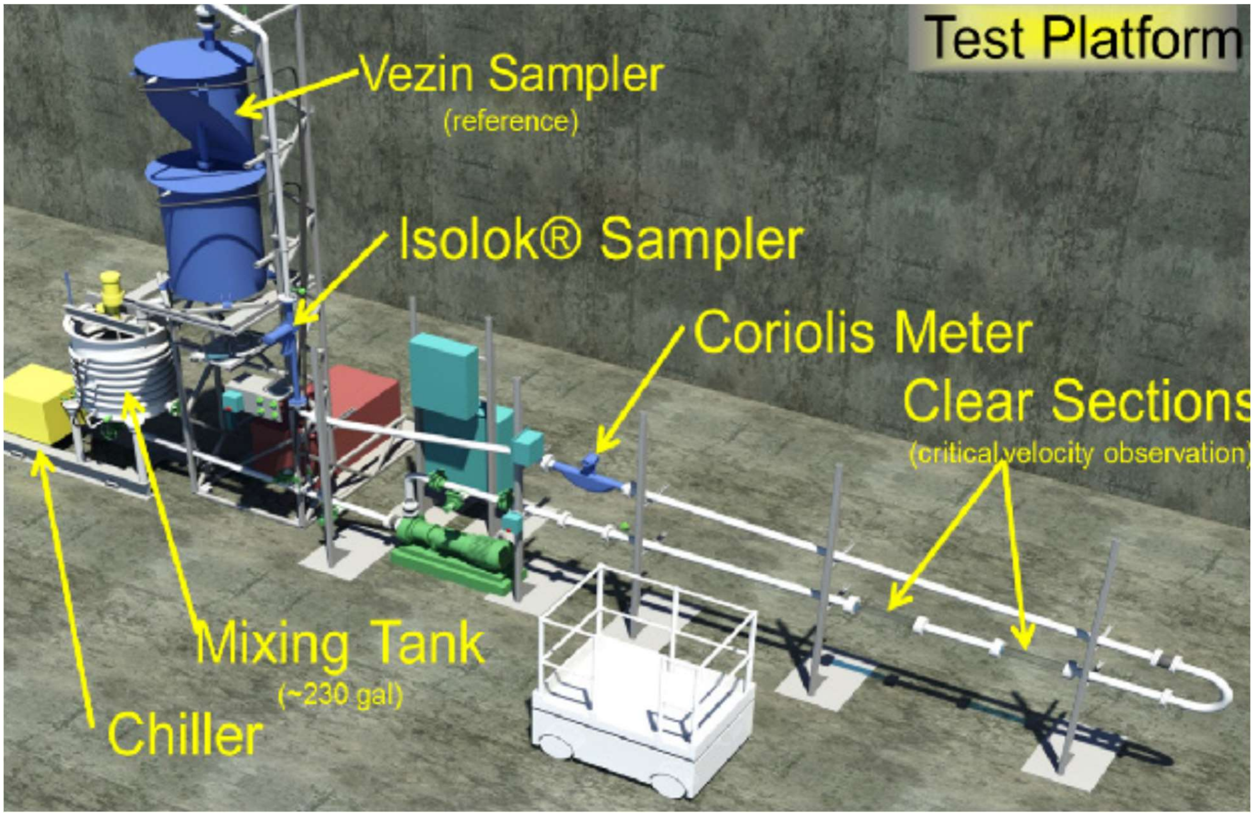
The Isolok sampler is a proposed system that would provide HLW acceptance samples to the WTP. The Isolok sampler uses a pipe-mounted plunger mechanism that enters the waste stream and collects many small aliquots over time to maintain representativeness. An online ultrasonic pulse echo (UPE) was integrated into the sample loop to allow for measurements of critical velocity.

The benefits of this technology is twofold:

- Allows for tank-side collection of online representative ≤ 1 liter HLW samples. The samples are evaluated for compliance with waste acceptance criteria and waste feed pre-qualification based on laboratory analysis.
- Prevents transfer line plugging by providing real-time slurry critical velocity measurements.

Technology development accomplishments include:

- Completed the design and fabrication of the Isolok sampler based on a previously proven WTP sampler design (ASX).
- Utilized a reference sampler based on world class expertise to validate and optimize representatives.



Isolock Sample Test Platform Layout

Tank Annulus Floor Cleaning – Complete (MTW-82) – Retired

In 2002, the primary tank walls of tank AY-101 were cleaned to remove excess corrosion product and debris accumulation. Through the process of cleaning the tank walls, the annulus floor was covered in the corrosion product and debris which caused problems for annulus floor ultrasonic inspection and annulus level monitoring.

This technology enables cleaning the tank walls and the annulus floor, covered in the corrosion product and debris. This enables ultrasonic inspection of the annulus floor, and annulus level monitoring. In FY 2019 after successful factory testing, Rolls-Royce engineers demonstrated the robotic cleaning system before WRPS and DOE engineers in Richland. WRPS operators were also trained on the system.

Accomplishments of this technology development are:

- Provided a system that mechanically moves debris and/or remove it from the tank annulus space via containers
- Design, fabrication, and factory acceptance testing completed
- Provided more annulus floor area for visual and nondestructive examination
- Prevent impact to ENRAF calibration within the tank AY-101 annulus

Tank AY-101 Annulus Floor Showing Debris

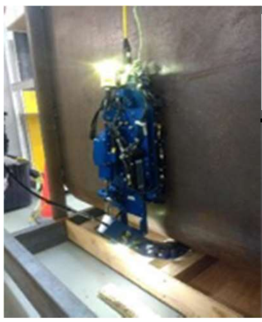
Annulus Floor Cleaner Mockup

Visual Inspection of DST Primary Tank Bottoms – Complete (MTW-15) - Retired

The primary liner bottom is currently a part of the tank that cannot be inspected. Visual inspection through the refractory air slots would provide an opportunity to inspect the primary tank bottom. The systems that were developed have given Tank and Pipeline Integrity (TAPI) the ability to access and visually inspect the primary tank bottom through the refractory air slot pattern underneath the DSTs for the first time since the tanks were put into commission.

Accomplishments of this technology development are:

- Provide access to the refractory slots underneath the DST primary shell
- Reduce the need to build new tanks at a cost of $200 million per tank
- May help serve to keep existing DSTs in safe operating conditions as long as possible



Primary Tank Bottom Inspection Crawler

Crawler to Delivery Camera Systems within Refractory Air Slots

Residual Volume Measuring System (RVMS) – On Going (RTW-02) – On Going

Technology development has been completed. This is a continuous improvement activity. A 6in capable laser is currently in use in the field. A smaller system is being tested to access the 2-in. risers. In addition, the integrity and shape of the tank walls and floors is important for tank waste retrieval and closure. More than one access port is being evaluated to attain an accurate tank scan due to obstructions.

4-in Capable Laser Scanner

6-in Capable Laser Scanner

Portable Gamma Radiation Monitoring System - Complete (RTW-11)- Retired

Gamma logging of ex-tank drywells is one method used for leak detection during SST retrievals. A hand-held gamma system, known as the Retrieval Drywell Monitoring System (RDMS), was developed and has been successfully deployed. The RDMS uses bar codes and a barcode reader for telemetry rather than a computer-controlled winch. This simpler telemetry system was key to making the system small enough for operators to transport gamma scan equipment into the farm without a vehicle. Modern handheld gamma scanner and probes are part of the new system. Hand-held moisture logging drywells is a currently used for leak detection screening. If changes in the moisture is detected, gamma scans are used to investigate the change. The RDMS will eliminate the need to screen for changes in moisture-reducing farm entries and will gather more definitive leak detection data.

Mobile Gamma Scanner

E3.0 Completed Technology Developments

The Roadmap is a living document. It is updated on an annual basis or as conditions warrant. As expected, during the performance of technology development, some technologies will be successfully completed, overcome by events, deemed unsuccessful, etc. During FY2021 and FY 2022, there were 9 TEDS retired. Table E-1 identifies the retired TEDS.

TEDS	Title	Basis for Retirement
MTW-09	Improved DST Annulus Camera System	Combined with MTW-20
MTW-36	Slurry Property Investigation	Combined with MTW-37
MTW-68	Mobile Proton Transfer Reaction – Mass Spectrometer	
PTW-24	Advanced Dynamic Simulation Modeling Platform	Need has been met
PTW-28	Operations Productivity and Analysis Tools	Need has been met
PTW-39	Virtual Workbench for Waste Processing	Need has been met
RTW-28	Improved Solubility Modeling of Oxalate, Fluoride, and other Simple Mixtures	Combined with RTW-27
RTW-29	Improved Solubility Modeling of Phosphate	Combined with RTW-27
RTW-33	Instrumentation for Detecting Plutonium Accumulations in Tanks	Deemed unsuccessful No Longer Pursued

APPENDIX F NATIONAL LABORATORY TECHNOLOGY CAPABILITIES MATRIX

F1.0 National Laboratory Technology Capabilities

To help ensure a successful DFLAW program, the ORP solicited support from the National Laboratories. Their task was to provide a recommended plan identifying capabilities, facilities, and resources. One goal was to minimize duplication of facilities, capabilities, and technical expertise. A second goal was to ensure ORP had sufficient support resources available in a timely manner that minimizes risk and operational down-time for resolution of technical issues occurring during operational phases. The result was an integrated task list describing the work type anticipated during start-up, commissioning, and operations, both initial and steady state.

The capabilities identified by the National Laboratories consist of eight Core Competencies. These are functional activities the National Laboratories deemed necessary to allow DFLAW operations to successfully complete commissioning, startup, and operation. These eight Core Competencies are:

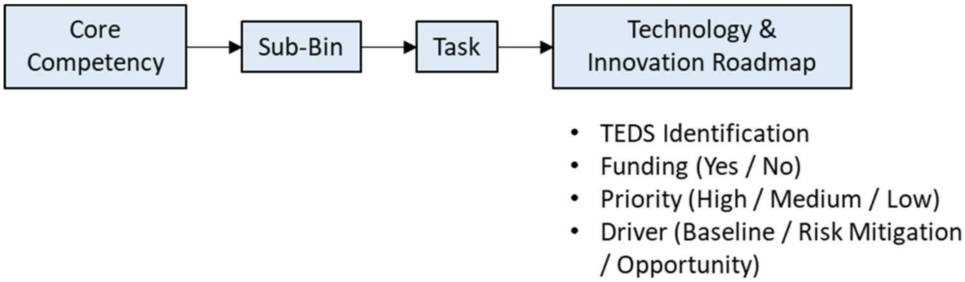
1. Material Integrity & Failure Analysis
2. Waste Forms
3. Analytical Laboratory
4. Process Engineering Support
5. Environmental Sampling & monitoring
6. Safety Analysis / Safety Basis Support
7. Remote Equipment Engineering
8. Independent Review Team

These categories are made up of one or more things having some common characteristics or purpose. Each Core Competency was further subdivided or decomposed into lower tier categories known as "sub-bins." These are subordinate groups that share a common differentiated quality. For example, waste forms can be cementitious, tank closure, waste disposal, or glass.

For each sub-bin, work tasks were identified. Tasks define a piece of work to be completed and finished within a certain time frame. Tasks were identified from lessons learned of previous operations across the DOE Complex, including the Defense Waste Processing Facility, Saltstone Operations, and Salt Waste Processing Facility at the Savannah River Site. The Core Competencies, sub-bins, and tasks were assembled and documented in a matrix.

WRPS reviewed the National Laboratories Capabilities Matrix and developed a crosswalk of existing technology development activities detailed on TEDS sheets. This crosswalk identifies and links technology development activities with the National Laboratories Core Competencies. Existing TEDS sheets were evaluated and documented if the matrix items were adequately addressed. In cases where the technology development requirement coverage needed to be expanded, either new TEDS sheets were identified or modifications to existing TEDS sheets were suggested. Funding status, priority, and Baseline/Risk Mitigation/Opportunity drivers are documented for identified TEDS sheets. Figure F-1 depicts the matrix information flow.

Figure F-1. National Laboratory Capability Matrix Decomposition.



An example of this information breakdown for Waste Forms Core Competency is shown in Figure E-2. Waste Forms Core Competency is divided into five sub-bins, each with one or more tasks, linked with Technology & Innovation Roadmap TEDS sheets.

Figure F-2. Core Competency - Waste Forms Example.

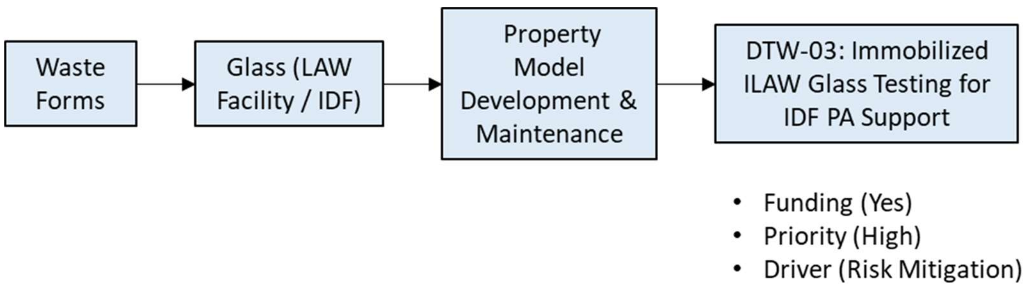


Table F-1 documents the National Laboratories Capabilities Matrix review results. The matrix was incorporated into the Roadmap via addendum RPP-PLAN-62988, *Addendum to the Technology and Information Roadmap Rev. 4*. Updates to the matrix are shown in white text. Retired TEDS sheets have been removed from the matrix.

Table F-2. National Laboratory Capability Matrix

National Labs Support Plan for DFLAW Startup, Commissioning, and Operation				
Core Competency	**Sub-Bin**	**Task**	**TEDS Sheet Identification Number**	**FY22 Funding?**
Material Integrity & Failure Analysis	Material Integrity & Failure Analysis	Materials Evaluation	RTW-10: Development Testing of High-Radiation Hose Materials	No
			MTW-84: Pipeline Forensic Inspection Technology	No
			MTW-85: Remote Profilometry Use for Surface Examination	No
		Structural Integrity Assessments	MTW-11: DST Primary Tank Bottom Volumetric Inspection	Yes
			MTW-09: Automated DST Annulus Camera System	No
			MTW-10: Phased Array UT Implementation for DST Walls	No
			MTW-20: Improve Visual Inspection	Yes
			MTW-78: In-Tank Volumetric Non-Destructive Examination	No
			MTW-87: Real-Time Localized Corrosion Monitor-Probe	Yes
			MTW-93: Cesium Online Monitoring for TSCR	No
			MTW-10: Phased Array UT Implementation for DST Walls	No
			MTW-92: Tank Repair	Yes
		Failed Component Evaluations	RTW-10: Development Testing of High-Radiation Hose Materials	No
			MTW-84: Pipeline Forensic Inspection Technology	No
Waste Forms	Grout / Cementitious Waste Forms - Liquid Secondary Waste and Supplemental LAW	Liquid Secondary Waste Bench-Scale Formulation & Testing / Facility Equipment & Design	MW-02: Ammonia Vapor Mitigation	Yes
			DTW-02: Low Temperature Waste Form Process	Yes
			PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			MTW-74: Measure Breathing Rates in Selected SX Tanks	No
			DTW-12: Evaluation of Natural Analogues to Support Tailored Grout	No
			DTW-13: Long-Term Durability of Cementitious Waste Forms	No
			DTW-14: Complex-Wide Database for Cementitious Waste Form Properties	No
	Grout / Microencapsulation - Solid Secondary Waste	Solid Secondary Waste Bench-Scale Formulation & Testing / Facility Equipment & Design	DTW-07: Solidification and Stabilization of Solid Secondary Waste	Yes
			DTW-08: IDF Long-Term Lysimeter Data Study	Yes
			DTW-13: Long-Term Durability of Cementitious Waste Forms	No
			DTW-14: Complex-Wide Database for Cementitious Waste Form Properties	No
	Closure	Closure	RTW-56: Technology to Support Risk-Based Retrieval and Closure	No
			RTW-25: Highly Flowable Grout	No
			RTW-01: Retrieval and Closure Solid Waste Sampling Tools	Yes
			RTW-54: Tank Waste Modular Treatment Study	No
			RTW-07: Post Waste Retrieval Updates to WMA C PA Maintenance	No
			DTW-13: Long-Term Durability of Cementitious Waste Forms	No
			DTW-14: Complex-Wide Database for Cementitious Waste Form Properties	No
	Glass (ILAW Facility / IDF)	Formulation and Testing	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-03: ILAW Glass Testing for IDF PA Support	Yes
		Property Model Development & Maintenance	DTW-03: ILAW Glass Testing for IDF PA Support	Yes
		Implementation of Glass Program	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
	Performance - IDF		RTW-07: Post Waste Retrieval Updates to WMA C PA Maintenance	No

National Labs Support Plan for DFLAW Startup, Commissioning, and Operation				
Core Competency	Sub-Bin	Task	TEDS Sheet Identification Number	FY22 Funding?
		Scenario Inputs to PA Baseline (IDF PA Inputs & Modeling)	RTW-39: Risk Informed Tank Retrieval Modeling Optimization	No
			PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-02: Low Temperature Waste Form Process	Yes
			DTW-03: ILAW Glass Testing for IDF PA Support	Yes
			DTW-08: IDF Long-Term Lysimeter Data Study	Yes
			DTW-13: Long-Term Durability of Cementitious Waste Forms	No
		Alternative PA Methodology	RTW-07: Post Waste Retrieval Updates to WMA C PA Maintenance	No
			RTW-39: Risk Informed Tank Retrieval Modeling Optimization	No
			PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-02: Low Temperature Waste Form Process	Yes
			DTW-03: ILAW Glass Testing for IDF PA Support	Yes
			DTW-08: IDF Long-Term Lysimeter Data Study	Yes
		Testing for IDF PA Inputs	DTW-07: Solidification and Stabilization of Solid Secondary Waste	Yes
			DTW-02: Low Temperature Waste Form Process	Yes
			PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-08: IDF Long-Term Lysimeter Data Study	Yes
Analytical Laboratory	Sample Characterization	LAW Feed Qualification	MTW-37: Tank Waste Characterization & Identification	Yes
		Rad Characterization	MTW-37: Tank Waste Characterization & Identification	Yes
			RTW-57: Plutonium/Absorber Mass Ratios Measurement	No
		Statistical Evaluation of Instruments	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		Standards Development	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		Procedures / Method Development / Training / Troubleshooting	MTW-41: Analytical Method Development for Compounds of Concern	Yes
			MTW-37: Tank Waste Characterization & Identification	Yes
	Real-Time / In-Line Monitoring	Real-Time / In-Line Monitoring	MTW-76: Online Monitoring Using Raman Spectroscopy	No
			RTW-31: In-Tank Sampling Technologies for Plutonium Particles	No
			MTW-87: Real-Time Localized Corrosion Monitor-Probe	Yes
			MTW-93: Cesium Online Monitoring for TSCR	No
Process Engineering Support	Overall Flowsheet	Campaign / System Plan Management / Support	PTW-42: High-Level Waste Direct Vitrification -- Condensate Treatment	No
			RTW-39: Risk Informed Tank Retrieval Modeling Optimization	No
			RTW-16: Develop an Integrated HLW Feed Qualification Plan	No
		Secondary Waste Composition Estimation	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-07: Solidification and Stabilization of Solid Secondary Waste	Yes
			MW-02: Ammonia Vapor Mitigation	Yes
		Key Analyte Tracking and Partitioning	MTW-57: Predicting Behavior of Mercury in EMF	No
			RTW-27: Improved Solubility Modeling of Aluminum	No
			RTW-28: Improved Solubility Modeling of Oxalate, Fluoride and Other Simple Mixtures	No
			RTW-29: Improved Solubility Modeling of Phosphate	No
			RTW-32: Neutron Poisons for Criticality Safety of Particulate Plutonium	No

National Labs Support Plan for DFLAW Startup, Commissioning, and Operation				
Core Competency	Sub-Bin	Task	TEDS Sheet Identification Number	FY22 Funding?
			PTW-45: Operations Productivity & Analysis Tools	No
			PTW-38: Radioactive Waste Test Platform	Yes
		Radioactive Test Platform	PTW-38: Radioactive Waste Test Platform	Yes
		Simulant Development / Optimization	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-07: Solidification and Stabilization of Solid Secondary Waste	Yes
			DTW-02: Low Temperature Waste Form Process	Yes
			RTW-16: Develop an Integrated HLW Feed Qualification Plan	No
			MW-02: Ammonia Vapor Mitigation	Yes
	Unit Operations	Tank Farm Retrieval / Equipment Testing / Mechanical Support	MTW-75: Super-Hydrophobic Metal Surface to Reduce Equipment Contamination	No
			MTW-50: Retrieval Support System	No
			RTW-01: Retrieval and Closure Solid Waste Sampling Tools	Yes
			RTW-15: Evaluate Back-Up Options for HLW Delivery from Tank Farms	No
			RTW-17: Access Deep Sludge Pump Reliability for DST Mixer & Transfer Pumps	No
			RTW-12: Development of New Riser Installation System	Yes
			RTW-34: Extended Reach Sluicing System Modifications	No
			RTW-08: Dry Waste Retrieval System (DWRS)	Yes
			RTW-55: Hanford Waste End Effector (Deployment Options)	Yes
			RTW-18: Improved Heat Removal for AW & AN Tanks TSR Heat Limits	No
			PTW-50: High-Level Waste Solids Segregation	No
			MTW-98: Long-Reach Robotic Tools for Tank Farm Pits	No
		Filtration	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
		Ion Exchange	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			PTW-48: Prevention of Hydrogen Gas Buildup	No
			PTW-49: Feasibility of Removing Nitrates from the LAW Feed	No
			MW-15: At-Tank Technetium and Iodine Removal and Disposition	No
		Vessel Mixing Evaluation and Sampling	RTW-16: Develop an Integrated HLW Feed Qualification Plan	No
		Slurry Transport	MTW-36: Slurry Property Investigation	Yes
		Glass Former Feed System	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		Melter Design Changes & Improvements Testing / Melter Operational Support	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		Container Handling / Decontamination Systems	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		Melter Offgas System	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			MW-02: Ammonia Vapor Mitigation	Yes
		Melter Condensate System	MW-02: Ammonia Vapor Mitigation	Yes
		Evaporation	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			MTW-90: Water/Waste Volume Measurement for 242-A C-A-1 Vessel	No
			MTW-91: Tank-Side Waste Evaporation	No
		Air Systems	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes

National Labs Support Plan for DFLAW Startup, Commissioning, and Operation				
Core Competency	**Sub-Bin**	**Task**	**TEDS Sheet Identification Number**	**FY22 Funding?**
	Unit Operations Troubleshooting	Statistical Process Evaluations	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		CFD, Line Plugging, and Transfer	RTW-23: Waste Transfer Pipe Unplugging	No
		LAW Pretreatment System	PTW-54: Real-Time Process Control for DFLAW	No
		Rheological Properties / Mixing Issues	PTW-23: Methods for Mitigating DFLAW Flowsheet Gaps	Yes
			DTW-07: Solidification and Stabilization of Solid Secondary Waste	Yes
			DTW-02: Low Temperature Waste Form Process	Yes
			MW-02: Ammonia Vapor Mitigation	Yes
		Scaling Fouling	MTW-89: Remote Concrete Surface Cleaning Apparatus	No
		Foam Control	PTW-53: DFLAW Process Operational Troubleshooting (NEW)	Yes
		Production Rate	RTW-43: Computer Simulator to Measure Retrieval Operator Skills	No
			RTW-21: Improve ESP – A Thermodynamic Modeling Program	No
			PTW-26: High- to Mid-Fidelity Consolidated Operators Training Simulator	No
			PTW-55: Chemical Process Modeling Software to Support DFLAW Operations	Yes
			MTW-97: Continued Need for Improving Tools for Tank Farm Projects	No
			MTW-99: Tank Farm Smart Operating Procedures	No
		Special Sample Support	MTW-74: Measure Breathing Rates in Selected SX Tanks	No
Environmental Sampling & Monitoring	Environmental Sampling & Monitoring	Vapors / Toxicology	MTW-24: Vapor Monitoring, Characterizing & Remediation	No
			MTW-40: Improve Sampling Methods of Head Space	No
			MTW-59: High Silica (Zeolite)-Containing PPE	No
			MTW-94: Internal Data Access & Visualization (IDAV)	Yes
			MTW-95: Data Fusion and Advisory System (DFAS)	Yes
		Tank Waste Inventory Monitoring	MTW-13: Improve Liquid Observation Well Data Acquisition	No
			MTW-71: Improve Best-Basis Inventory with TWINS Database	No
			RTW-44: Use of Sonar & Ultrasound to Quantify Solids in DSTs	No
			RTW-57: Plutonium/Absorber Mass Ratios Measurement	No
		Corrosion Control	MTW-77: Large-Volume Supernatant Sampler & Transportation System	Yes
			MTW-09: Automated DST Annulus Camera System	No
			MTW-11: DST Primary Tank Bottom Volumetric Inspection	Yes
			MTW-73: Tertiary Leak Detection and Foundation Robotic Inspection	No
			MTW-10: Phased Array UT Implementation for DST Walls	No
			MW-10: Remotely Operated or Automated ETF Internal Tank Cleaning Device	No
			MTW-86: Protective Measures for Waste Transfer System Lines	No
			MTW-83: Secondary Liner Bottom Damage Mitigation Technologies	No
			MTW-87: Real-Time Localized Corrosion Monitor-Probe	Yes
		Stack Monitoring	MTW-24: Vapor Monitoring, Characterizing & Remediation	No
			MTW-77: Large-Volume Supernatant Sampler & Transportation System	Yes
Safety Analysis / Safety Basis Support	Safety Analysis /	Safety Analysis / Safety Basis Support	MTW-70: Plutonium Particulate Criticality Safety Issue Resolution	No
	Remote Equipment Engineering	Sampling System Design	MTW-77: Large-Volume Supernatant Sampler & Transportation System	Yes

National Labs Support Plan for DFLAW Startup, Commissioning, and Operation				
Core Competency	**Sub-Bin**	**Task**	**TEDS Sheet Identification Number**	**FY22 Funding?**
Remote Equipment Engineering			MTW-88: Liquid Air Interface Sampler	No
		Transportation, Packaging and Material Handling	MTW-77: Large-Volume Supernatant Sampler & Transportation System	Yes
		LAW Container Loading / Transport / Unloading at IDF	DTW-06: Advance Offsite Transportation Capability	No
		Secondary Waste Handling Systems	MTW-09: Automated DST Annulus Camera System	No
			MTW-10: Phased Array UT Implementation for DST Walls	No
		Specialized Tool Design &Remote Equipment Modifications	MTW-79: Autonomous Robotic Platform	Yes
			MTW-81: Radiation-Tolerant Multi-Use Manipulator System	No
			MTW-72: Self-Diagnosing Continuous Air Monitoring	No
			MTW-80: Automated Visual Recognition Wireless Remote Video Monitoring	No
			RTW-08: Dry Waste Retrieval System (DWRS)	Yes
			RTW-34: Extended Reach Sluicing System Modifications	No
			RTW-55: Hanford Waste End Effector (Deployment Options)	Yes
			RTW-03: Remote Tank Farm Above Ground Inspections	No
			RTW-12: Development of New Riser Installation System	Yes
			MTW-83: Secondary Liner Bottom Damage Mitigation Technologies	No
			MTW-84: Pipeline Forensic Inspection Technology	No
			MTW-85: Remote Profilometry Use for Surface Examination	No
			MTW-89: Remote Concrete Surface Cleaning Apparatus	No
			MTW-98: Long-Reach Robotic Tools for Tank Farm Pits	No
			MTW-100: Increased NDE Volumetric Inspection	No
Independent Review Team	Independent Review Team	Readiness Assessment Reviews	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes
		Test Plans for Start-Up / Commissioning	PTW-53: DFLAW Process Operational Troubleshooting (New)	Yes

APPENDIX G INNOVATIONS

Core Catcher

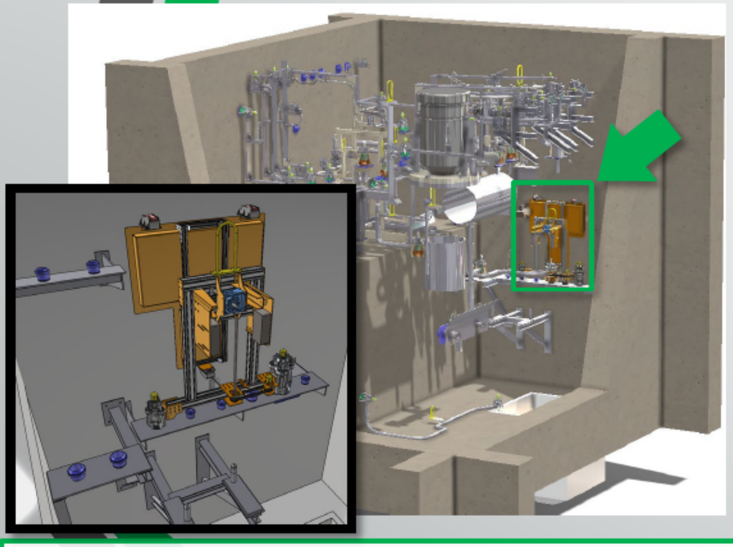
Collects core drilling waste and prevents workers from needing to enter highly contaminated 242-A Evaporator Pump Room

✓ REDUCED WORKER DOSE | ✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ COST REDUCTION

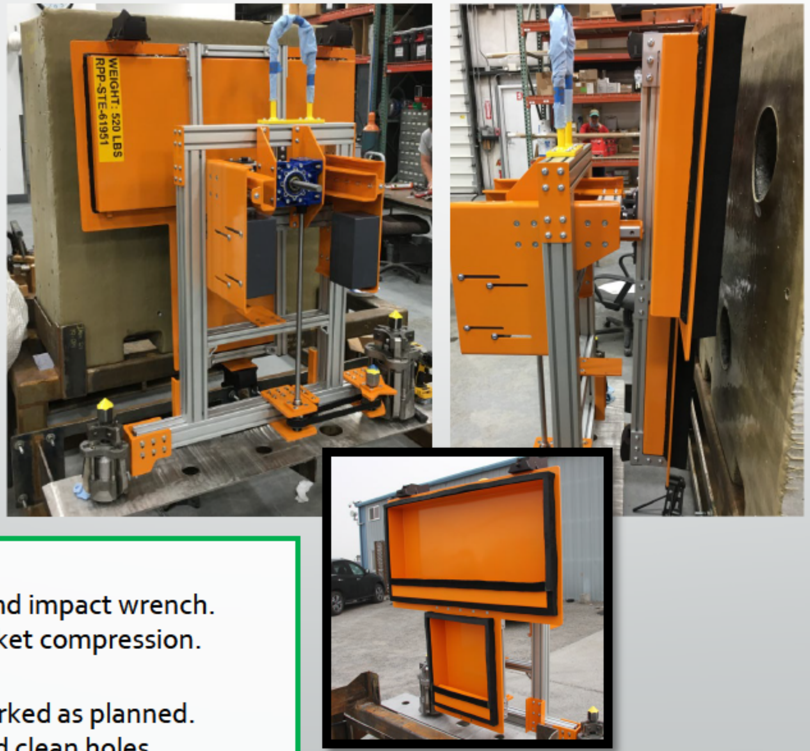
PROBLEM: The replacement transfer lines for the 242-A Evaporator require core drilling through the evaporator pump room wall in multiple locations to install nozzles. Core drilling has the propensity to eject debris from the side opposite the drill in the form of spalling, broken-off cores, and cutting fluid. This debris should be prevented from falling into the Pump Room. The nozzle locations are approx. 10-12 ft. above ground level and installing equipment for manned entry is both complicated and time consuming. The Pump Room is posted as a High Contamination Area.

SOLUTION: Design, fabricate, test, and deploy a system that can prevent debris from entering the Evaporator Pump Room. The system must negate the need for worker access to this area and be remotely installed using only the Evaporator Bridge crane and impact wrench. Correct positioning of the system shall be achieved via indicators that are visible from the viewing windows of the Pump Room.

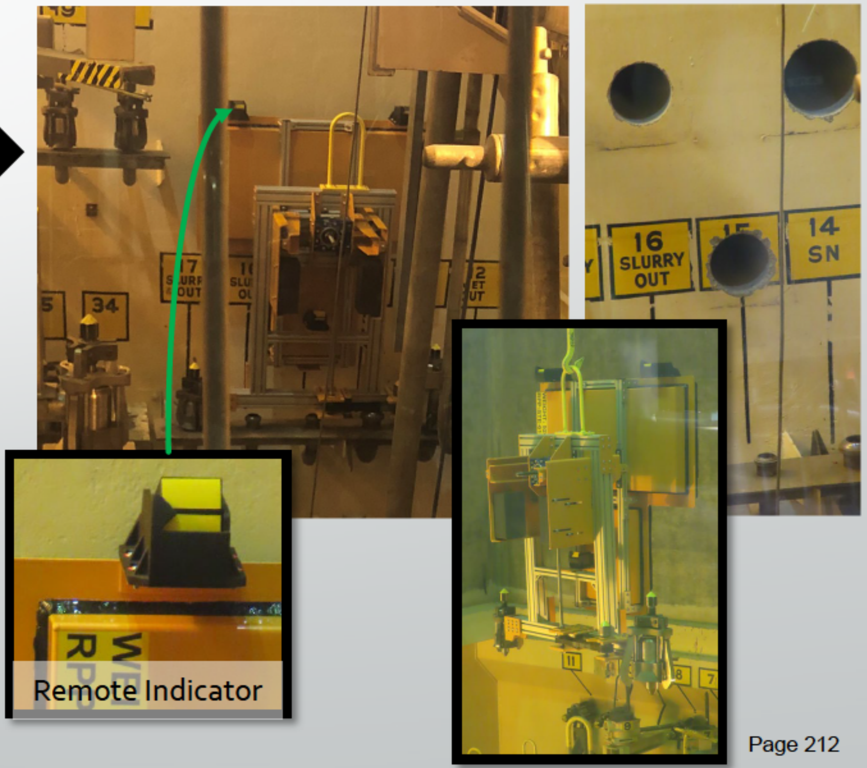
Core Catcher Design in Pump Room



Fabrication/Testing



Installation and Use



INNOVATIVE FEATURES:

- Can be installed and operated using only the bridge crane and impact wrench.
- Utilizes 3D printed remote indication system to identify gasket compression.

IMPLEMENTATION HIGHLIGHTS:

- Fit-up and interface with the pump room impact wrench worked as planned.
- All the core drilling debris/slurry was captured leaving behind clean holes.
- Duration for installation and removal/disposal was ~30 minutes each.

Lead POC - Peter Griffin | Year Developed - 2020 | Tool Evaluation - RPP-STE-61951

Core Drill Guide Assembly

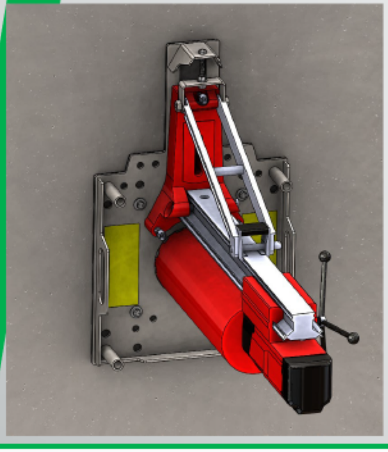
Allows accurate placement of the core drill and associated concrete anchors while maximizing worker safety

✓ INCREASED SYSTEM RELIABILITY | ✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ REDUCED SCHEDULE

PROBLEM: Accurately positioning core drill assemblies horizontally against a concrete wall is an industry problem that requires time and accessibility to properly complete. Neither of these solutions are available in Tank Farms. Improper placement can result in the inability to install the new transfer line wall nozzle adequately resulting in rework or less than desirable design changes to account for the as-built location.

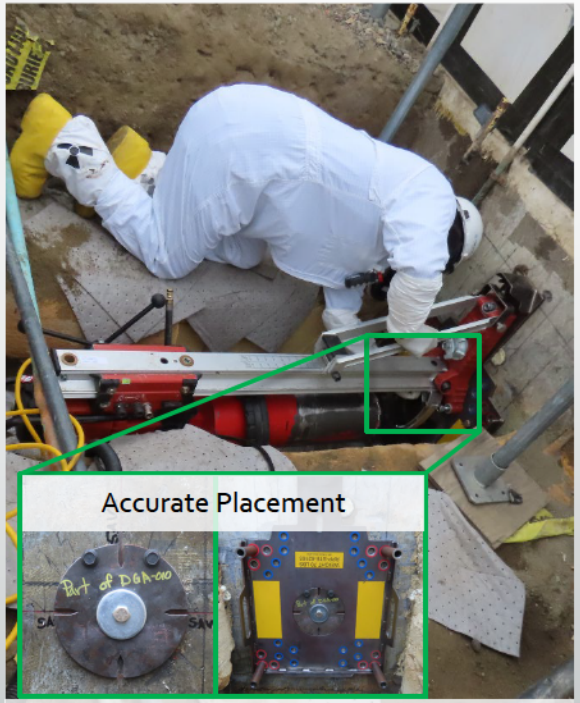
SOLUTION: Design, fabricate, test, and deploy the necessary tools to allow precision placement of a core drilling machine (Hilti DD-250) and associated wall nozzle anchors. The solution will allow fine tune adjustments via designed features to increase placement efficiency while maximizing worker safety. The designed solution will also incorporate pre-planned anchor drilling sleeves to allow the accurate anchor placement/alignment with minimal accessibility.

Drill Guide Design



Drill Guide Fab and Testing

Core Drill Guide Use For Successful Core Drill at AW-B Valve Pit



Accurate Placement

Installation of Drill Guide and Core Drill

Drilling for Anchors Via Alignment Sleeves

Accurate Core

Accurate Anchors

INNOVATIVE FEATURES:

- Easy to install/locate drill guide assembly utilizing surveyed alignment marks.
- Fixture attachment points to allow core drill unit positioning with a turn of a wrench versus physically lifting components in awkward body positions.
- Alignment sleeves to support drilling final nozzle mounting anchors minimizes risk for interface issues during the rest of the nozzle installation.

IMPLEMENTATION HIGHLIGHTS:

- Easy and precise installation with positive worker feedback.
- Resulted in exceptional core placement and anchor alignment.

Return on Investment = 1.6 | Hazard Mitigation = Moderate | Estimated Dose Savings = 64 Person - mrem

Lead Point of Contact - Peter Griffin | *Year Developed* - 2020 | *First Used* - 2021 | *Tool Evaluation* - RPP-STE-62165

Core Drill Wall Clamp

Alleviates legacy problems associated with spalling during pit wall coring and subsequent pit repair

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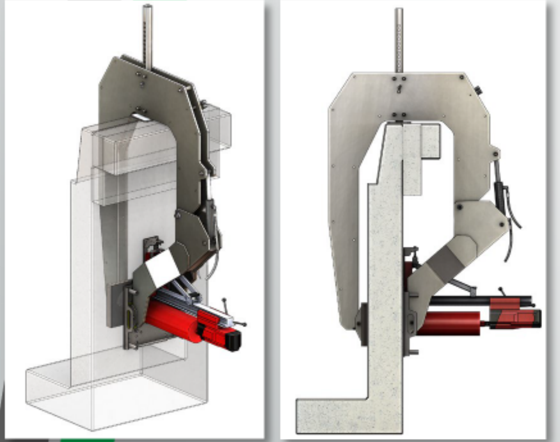
✓ REDUCED WORKER DOSE | ✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ REDUCED SCHEDULE

PROBLEM: Lessons learned from historical core drill spalling required a different approach to mitigate damage when the core drill bit breaches through the pit inside wall. In addition, the AW-B valve pit special protective coating is polyurea which resists cutting. The coating wants to delaminate from the pit wall before the drill bit can cut through. If this were to happen, installation of a new wall nozzle would be extremely challenging.

SOLUTION: Design, fabricate, and deploy the necessary tool to allow precision placement and sufficient compression against the inside pit wall to prevent any concrete spalling or separation of the special protective coating. This tool interfaces with the wall nozzle installation fixture plates and will be deployed to various structures to support wall nozzles installations in AW-Farm for the 242-A Replacement Transfer Line Project.

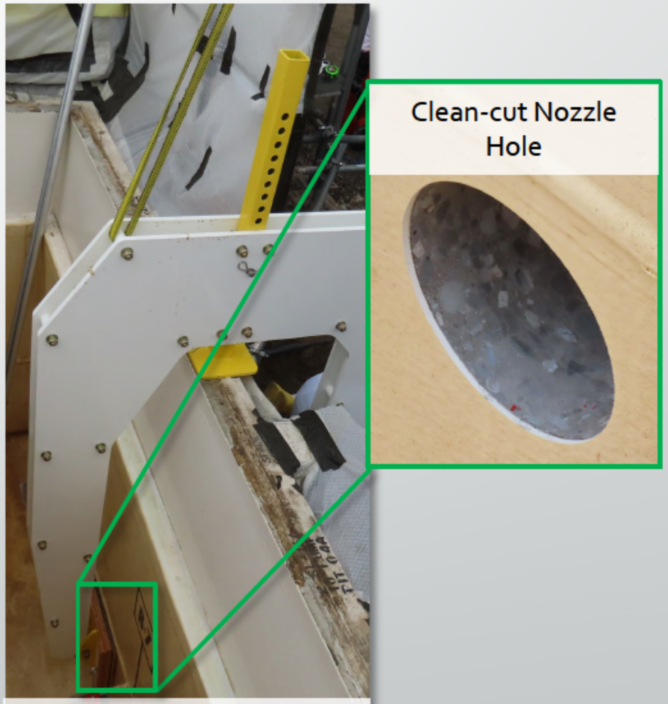
Wall Clamp Design



Wall Clamp Fab and Testing

Wall Clamp Installation and Use For Successful Core Drill at AW-B Valve Pit

Installation of Wall Clamp



Wall clamp installed in pit

INNOVATIVE FEATURES:

- Low-profile, field-configurable design provides installation flexibility to support the multiple new wall nozzle installations.
- Provides constant clamping pressure to pit will during drilling to minimize spalling and coating delamination.
- Simple operation yields fast installation time.

IMPLEMENTATION HIGHLIGHTS:

- Streamlined and precise installation.
- Resulted in a flush core drill to support successful wall nozzle installation.

Return on Investment = 3.4 | Hazard Mitigation = Moderate | Estimated Dose Savings = 600 Person - mrem

Lead Point of Contact - Doug Kennedy | *Year Developed* - 2020 | *First Used* - 2021 | *Tool Evaluation* - RPP-STE-62087

Hydraulic Pipe Bender

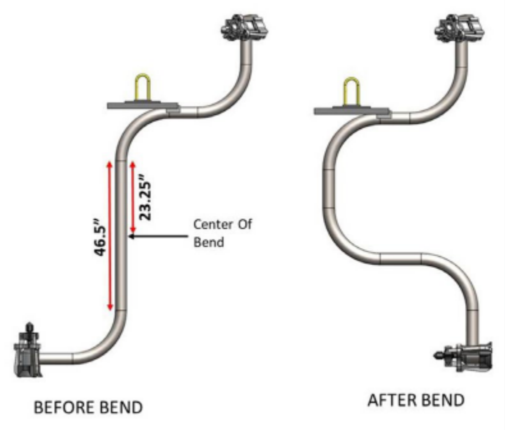
Allows safe bending of jumpers for disposal while preventing size reduction via higher risk cutting methods

✓ REDUCED WORKER DOSE | ✓ REDUCED SCHEDULE | ✓ INCREASED TASK EFFICIENCY | ✓ INCREASED WORKER SAFETY

PROBLEM: Jumpers located in the 242-A Evaporator pump room contain long runs of piping to facilitate connections between Purex nozzles. These jumpers cannot fit in a standard size waste container to allow shipment to ERDF without size reducing the piping. Previous size reduction methods require implementing an engineering control, a glove bag, and breaching/cutting into the piping. This process poses worker contamination hazards and is time consuming.

SOLUTION: Procure, test, and deploy the equipment needed to allow the reconfiguration of the jumper piping to fit within a waste container. The solution will allow the project to move up the hierarchy of controls by eliminating the contamination hazard via controlled bending of the jumper piping into a specific configuration.

Develop Execution Plan

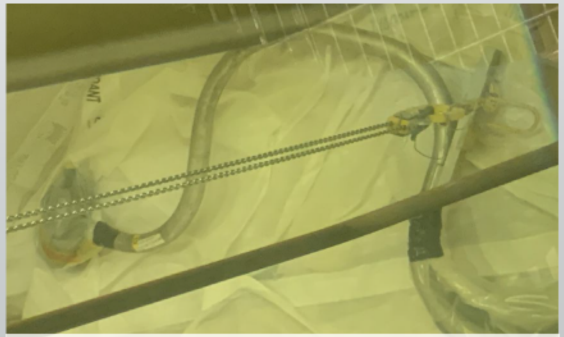


Testing

Successful Jumper Pipe Bending and Placement in a Waste Container


Jumper Removal and Stage for Bending


Jumper Being Bent


Jumper Bending Completed


Jumper Disposal

INNOVATIVE FEATURES:
- Utilizes commercial off the shelf equipment for immediate deployment without any design development.
- System sized for providing reliable bend radius on 3-inch Sch. 40 stainless steel pipe with a single stroke/push.
- Compact and portable system allowing easy/rapid field deployment.

IMPLEMENTATION HIGHLIGHTS:
- Workers had the bender installed, bend completed, and jumper in the waste container in less than 1 hour.
- Dose rates of open jumper ends prior to containing them suggest internal areas of the jumper contamination levels were up to ~ 56,000,000 dpm/100 cm^2 beta-gamma.

Return on Investment = 3.5 | Hazard Mitigation = High | Estimated Dose Savings = 96 Person - mrem

Lead Point of Contact - Jason Engeman | *Year Developed* - 2020 | *First Used* - 2021

Integrated Pressure Washer System

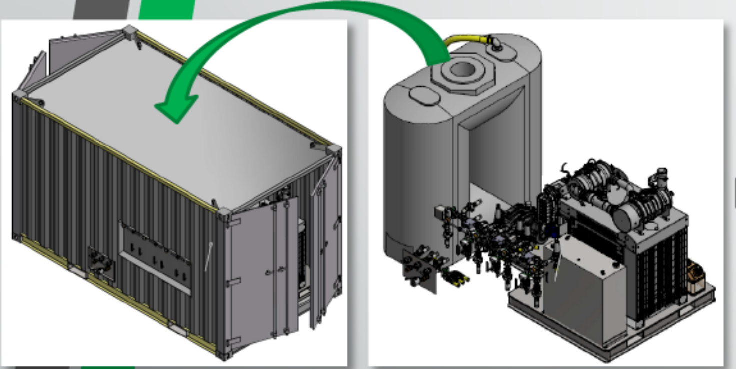
Complete, high-pressure water delivery system for decontamination of Long-Length Equipment

✓ REDUCED WORKER DOSE | ✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ COST REDUCTION

PROBLEM: In order to reduce the dose rate of long-length equipment removed from waste tanks, high-pressure water is used in conjunction with specialty decon equipment to rinse large amounts of contamination from the item during removal. An integrated system that requires minimal setup time and delivers more water at higher pressure is desired. In addition, the existing setups struggle to minimize water additions due to lack of controls to start/stop the system at the location of the field crew. This disadvantage equates to more water added to the tank consuming tank space.

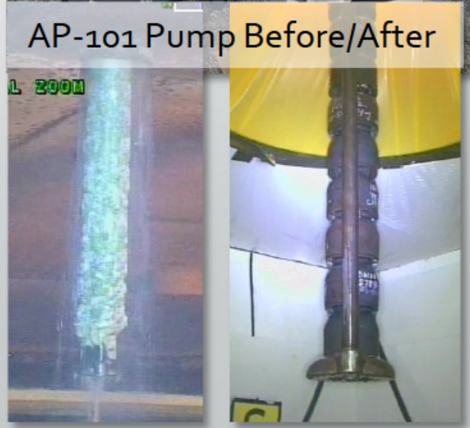
SOLUTION: Develop and procure a high pressure water delivery system that integrates all the core components needed to facilitate rinsing of long-length equipment into a single, transportable package. The solution shall be able to deliver enhanced flexibility and capability to support current and future equipment removal. The unit will include the capability to utilize a pendant to allow field crew controls close to the equipment removal area. This capability will reduce total water used and minimize the chances of challenging water addition OSD limits.

Design Development



Testing

Deployment



INNOVATIVE FEATURES:

- Remote operation allows water to be started and stopped immediately, rather than relying on walkie-talkie communication, resulting in less wasted water introduced to waste tanks.
- The entire system is self contained
- Ability to connect multiple cleaning devices and remotely toggle between them
- Compact footprint reduces space needed for mobilization

IMPLEMENTATION HIGHLIGHTS:

- Over 200% higher water flow rate and 50% higher water delivery pressure than previous system
- Extremely effective cleaning for AP-101 pump removal while using less than 900 gallons.

Return on Investment = TBD* | Hazard Mitigation = Moderate | Estimated Dose Savings = TBD*

* EVALUATION IN PROGRESS

Lead Point of Contact - Peter Griffin | *Year Developed* - 2019 | *First Used* - 2021

Long-Length Internal Pipe Grinder

Rapidly-executed tool for removing internal pipe interferences for Evaporator Feed Pump installation

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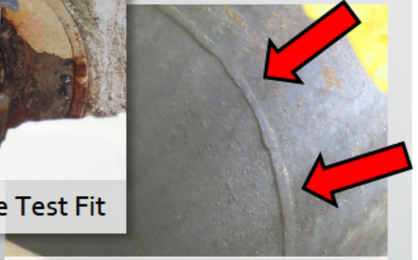
✓ RAPID DEPLOYMENT | ✓ INCREASED WORKER SAFETY | ✓ REDUCED WORKER DOSE | ✓ SCHEDULE-SAVING

PROBLEM: During replacement of the AW-02E pump, a restriction in the pit riser was identified that would prevent the new pump from being installed. This was discovered using the go/no-go gauge the project fabricated to ensure there would be no fitment issues during the pump installation. The restriction was determined to be a weld bead left over from tank construction. Grinding in this area is high-hazard, high-dose work and would typically require a manned pit entry in the 10-ft deep pit.

SOLUTION: Design, fabricate, test, and deploy a long length remotely-operable tool and associated equipment capable of removing the weld interference located below a pit work platform, ~16" down inside the pit riser. The tool must prevent the need for a manned pit entry, be installed/removed by hand, and be delivered as fast as possible to minimize impacts to the project schedule.

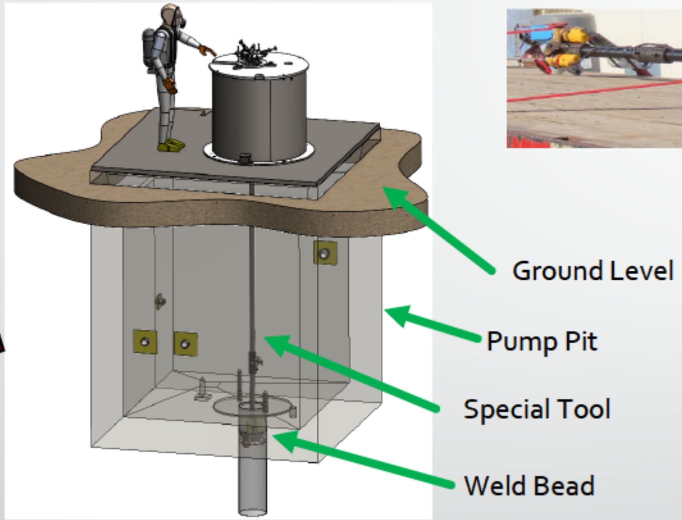
Problem Identification

Go/No-Go Gauge Test Fit



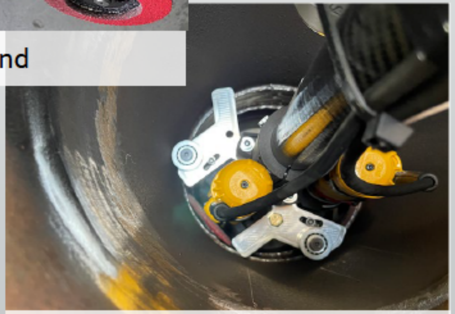
Weld Protrusion Requiring Removal (~3/16" High)

Tool Design



Fabrication and Testing

Grinder End



Test Grinding in Mock-Up Pipe

Field Implementation

Tool Operation

Tool Installation

INNOVATIVE FEATURES:

- Heavy use of rapid manufacturing techniques like 3D Printing, rapid-turn CNC parts, 3D scanning and DFx (Design for 'X') methodology allowed for rapid development of the tool.
- Allowed remote control and pressure application of grinders to the weld area.

IMPLEMENTATION HIGHLIGHTS:

- Design to Deployment in 3 weeks
- The tool successfully removed the interferences and mitigated schedule upset

Return on Investment = 1.7 | Hazard Mitigation = High | Estimated Dose Savings = 4,800 mrem

Point of Contact - Peter Griffin | *Year Developed* - 2021 | *Tool Evaluation* - RPP-STE-63290

Mini Conveyor System for Excavation

Increase worker safety during excavation with a simultaneous significant increase in productivity

✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ REDUCED SCHEDULE | ✓ COST REDUCTION

PROBLEM: Manual excavation techniques require significant labor resources to move dirt from the bottom of trenches to containers for disposal. This often involves a sequence of dirt moves through shovels, 5-gal buckets, tracked mud buggies, front loaders, etc. At any given time when these components become full, the value-added excavation stops, creating large inefficiencies. In addition to the inefficiencies, there are fatigue and ergonomic considerations when removing dirt in this manner.

SOLUTION: Implement an easily deployable conveyor belt system which allows excavated dirt to move from shovel to front loader directly (remove as many intermediate steps as possible). This system will work in trenches from grade elevation to 7+ feet deep. The system will be light weight (moved by hand), easily configured, 120V powered, and capable of moving a wide range of dirt/rock through multiple stages/directions. Similar system were first identified during the 2020 ConExpo.

Market Research

Field Implementation

Video available upon request

INNOVATIVE FEATURES:

- Commercially available item that is easily purchased and user intuitive.

IMPLEMENTATION HIGHLIGHTS:

- Laborers and supervisors were extremely pleased with the ease of setup/use and significant reduction in overall physical effort required to perform excavations.
- Within the first day of implementation, excavation productivity increased 50-100%.

FUTURE IMPLEMENTATION:

- Due to a high level of adoption and shift in crew preference, more Mini Conveyors are being ordered to further assist with deeper excavations planned for early FY22.
- Use being considered to support Retrieval & Closure project excavations.

Return on Investment = 3.5 | Hazard Mitigation = Medium | Estimated Dose Savings = Low

Lead Point of Contact - Matt Huntington | *Year Developed* - 2021 | *First Used* - 2021

Modular Extended-Reach Hacksaw

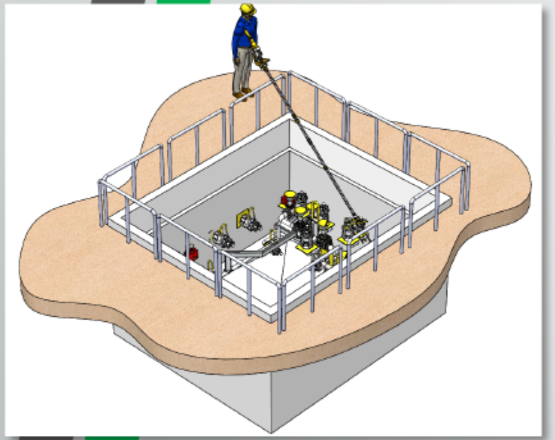
Adaptable solution for remote material cutting without pit entry

✓ REDUCED WORKER DOSE | ✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ COST REDUCTION

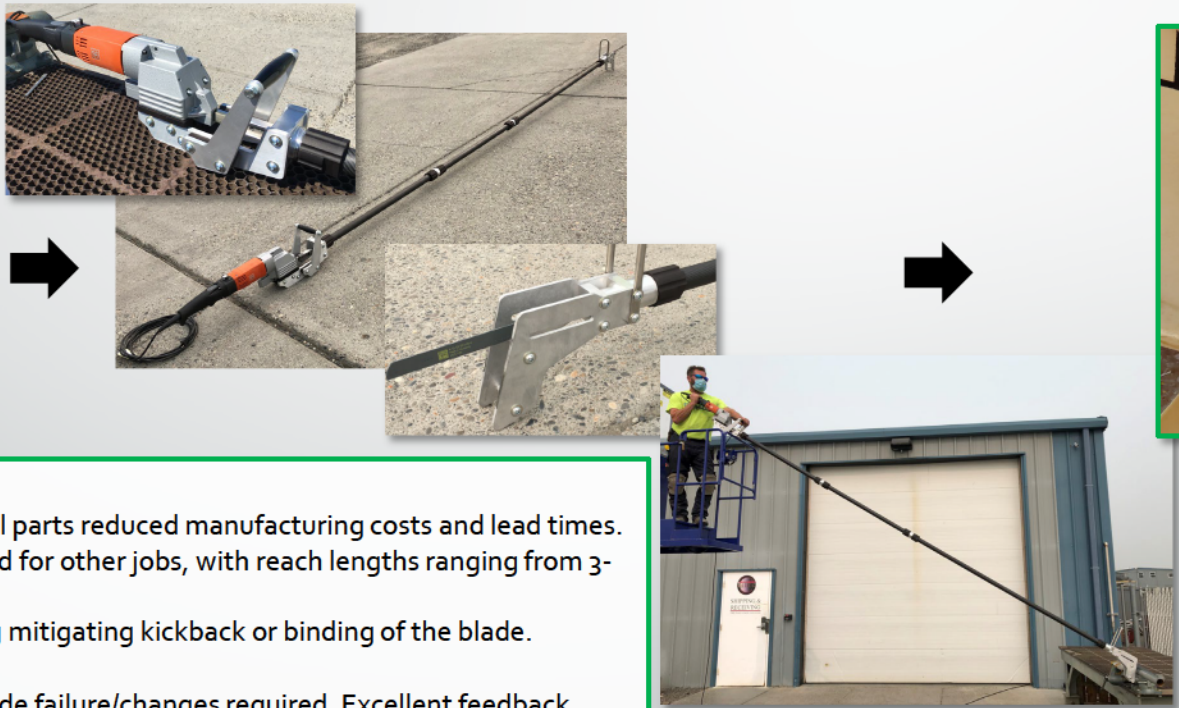
PROBLEM: Existing legacy waste transfer pit nozzle required removal to allow sufficient clearance for future jumper installations. Manned entries are high risk, costly, and lengthy activities. Remote tooling to perform the same task is preferred.

SOLUTION: Design, fabricate, test, and deliver a cutting tool to allow the removal of the legacy wall nozzle. The tool will have a range of capabilities to allow it to perform similar activities in various configurations if those instances arise.

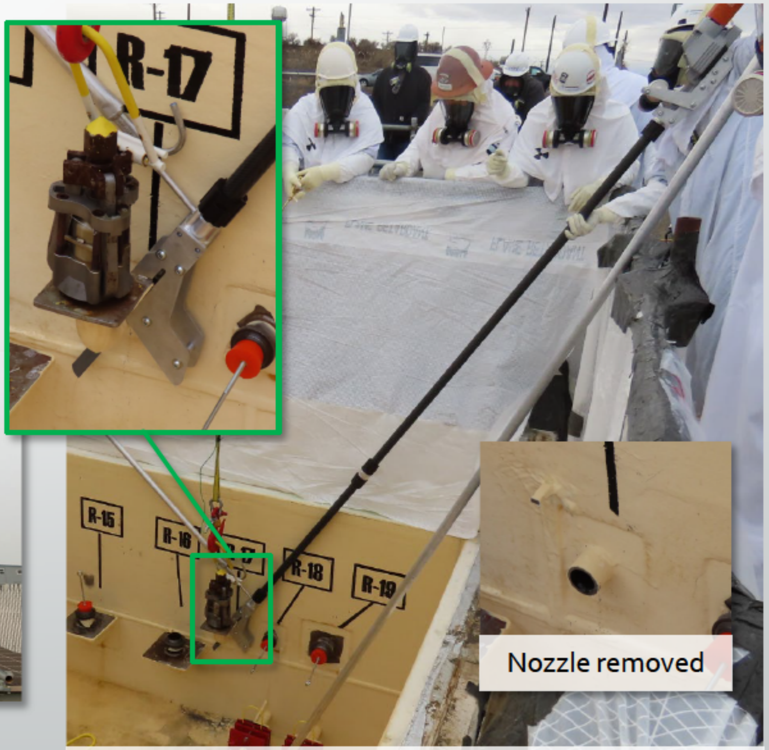
Saw Design



Fabrication and Testing



Field Implementation



Hacksaw in use removing wall nozzle

INNOVATIVE FEATURES:

- Use of 3D-Printed components on the final parts reduced manufacturing costs and lead times.
- Modular shaft design allows tool to be used for other jobs, with reach lengths ranging from 3-ft to 12-ft long.
- Blade guide system allows for easy cutting mitigating kickback or binding of the blade.

IMPLEMENTATION HIGHLIGHTS:

- Total cutting time ~10 minutes with no blade failure/changes required. Excellent feedback from the field crew.

Return on Investment = 1.6 | Hazard Mitigation = Moderate | Estimated Dose Savings = 75 Person - mrem

Lead Point of Contact - Peter Griffin | *Year Developed* - 2020 | *First Used* - 2021 | *Tool Evaluation* - RPP-STE-62095

Nozzle Mounting Plate Assembly

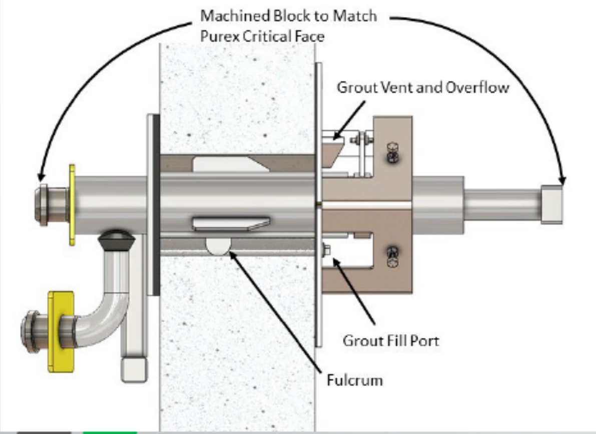
Allows precise placement of the new wall nozzle assembly on the first attempt

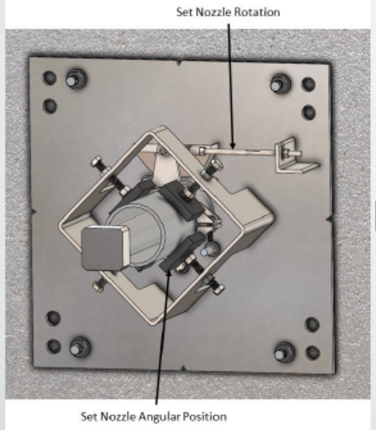
✓ INCREASED SYSTEM RELIABILITY | ✓ REDUCED SCHEDULE | ✓ INCREASED TASK EFFICIENCY | ✓ INCREASED WORKER SAFETY

PROBLEM: Wall nozzle assemblies contain Purex nozzles that future jumpers will connect to for waste transfers. Poorly installed nozzles could increase the chance of fail leak checks and rework of jumpers prior to turn over to operations. Pit wall surface placement (e.g. interior pit face is not perfectly straight) and other original construction features will prevent precise nozzle placement without several iterations of interim placement and surveying which extends the project schedule.

SOLUTION: Design, fabricate, test, and deploy the necessary fixture to allow the precise placement of the wall nozzle. The mounting plate will complement design features on the nozzle assembly to be able to be positioned in place with only access on the outside wall of the pit. The ability to measure the angular position of the Purex nozzle will also be performed with only access on the outside wall of the pit.

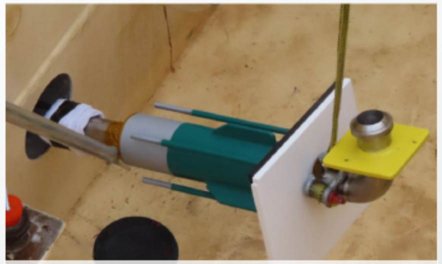
Example Wall Nozzle Installation Setup





Testing and Mock-Up

Successful Nozzle Installation and Placement at AW-B Valve Pit



Installation of Wall Nozzle

Setting Nozzle Position

Achieved Desired Results

INNOVATIVE FEATURES:

- A machined block was added to the end of the primary pipe to match the Purex nozzle critical face. Allows crew to manipulate the nozzle to the desired position and use the machined block for checking alignment.
- A fulcrum feature was added to the wall nozzle to allow jacking feet on the mounting plate to set the angular position of the nozzle.
- A clamp that goes around the encasement allows for the rotation of the wall nozzle to achieve the correct position.

IMPLEMENTATION HIGHLIGHTS:

- Workers had the nozzle installed and positioned in approximately 30 minutes.
- Post installation laser scan results showed the nozzle was positioned within 1/10 of a degree of perfectly level on the first attempt, well within tolerance.

Return on Investment = 1.6 | Hazard Mitigation = Low | Estimated Dose Savings = 112 Person - mrem

Lead Point of Contact - Jason Engeman | *Year Developed* - 2020 | *First Used* - 2021 | *Tool Evaluation* - RPP-STE-62165

Pipe Cap Sizing and Installation Tools

Simple, reliable tools for measuring and installing pipe caps without pit entry

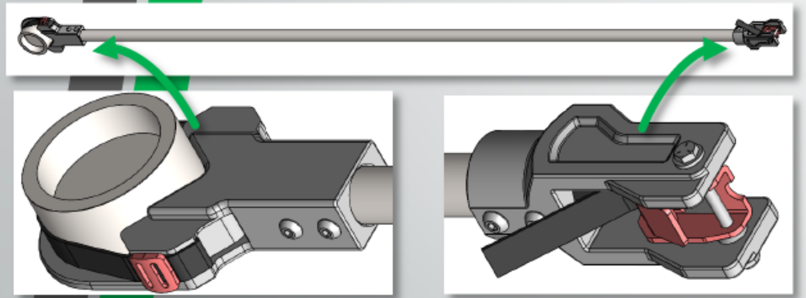
✓ REDUCED WORKER DOSE | ✓ INCREASED SYSTEM RELIABILITY | ✓ INCREASED TASK EFFICIENCY | ✓ REDUCED SCHEDULE

PROBLEM: After the wall nozzle in the AW-B valve pit was cut off by the extended reach hacksaw, a pipe cap needed to be installed. Due to the build-up of polyurea coating on the piping and its proximity from the workers determining the size and installing the pipe cap remotely would prove to be tedious and time consuming without an engineered solution.

SOLUTION: Design, fabricate and deploy the necessary components to allow crews to assemble a remote pipe cap sizing tool and cap installation tool. The sizing tool will allow crews to determine the appropriate size cap to deploy. The installation tool will allow crews to secure and install the cap without risk of dropping it into the pit potentially damaging the coating and delaying work.

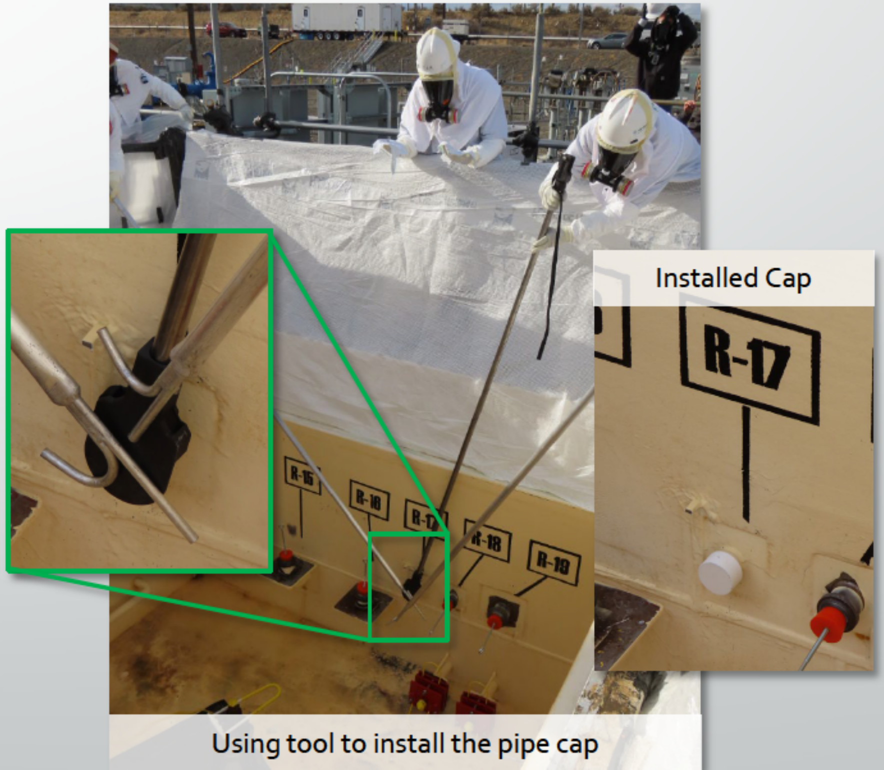
Cap Sizing Tool Design

Cap Installation Tool Design



3D-Printed Parts Fabrication

Successful Installation of Pipe Cap



Installed Cap

Using tool to install the pipe cap

INNOVATIVE FEATURES:

- Use of 3D-Printed components on the final parts reduced manufacturing costs and lead times, making the tools quickly available for field implementation.
- Allows for a range of pipe cap sizes to be measured and installed via the same tools providing flexibility to field crews.
- Provides a secure means of deploying the cap (i.e. tension on strap held by a cam buckle) allowing workers to focus on the installation and not on maintaining a grip on the cap.

IMPLEMENTATION HIGHLIGHTS:

- Total time from point of sizing to cap installed was approximately two minutes with no issues.

Return on Investment = 1.6 | Hazard Mitigation = Moderate | Estimated Dose Savings = 45 Person - mrem

Lead Point of Contact - Peter Griffin | *Year Developed* - 2020 | *First Used* - 2021 | *Tool Evaluation* - RPP-STE-62835

Pump Room Core Drilling and Wall Nozzle Installation

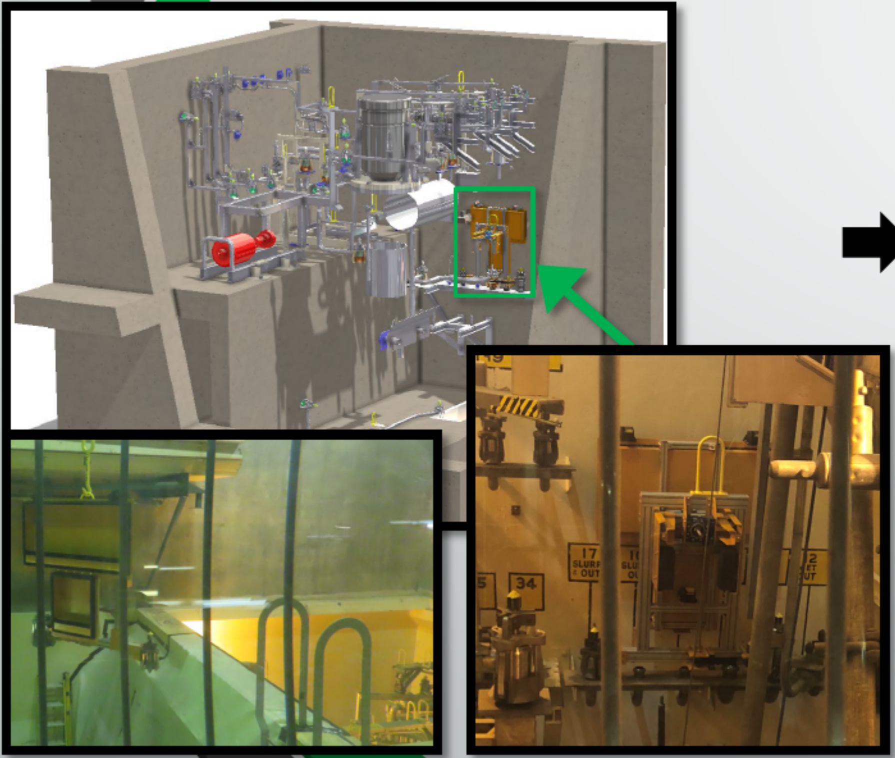
Tool suite which prevents workers from needing to enter highly contaminated 242-A Evaporator Pump Room

✓ REDUCED WORKER DOSE | ✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ COST REDUCTION

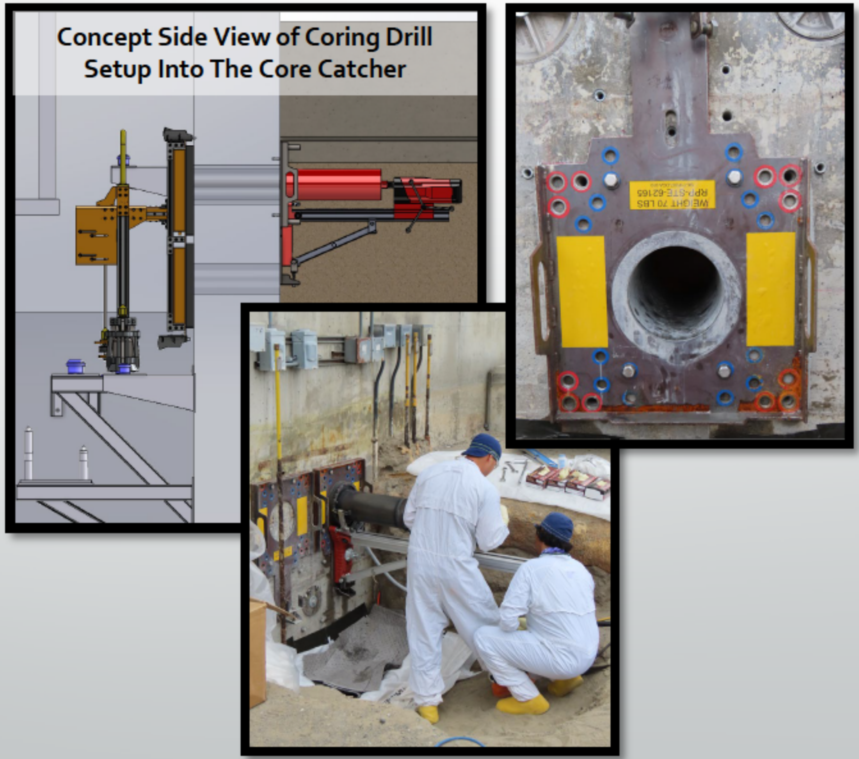
PROBLEM: The replacement transfer lines for the 242-A Evaporator require core drilling through the 22-in thick evaporator pump room wall in multiple locations to install new wall nozzles. Core drilling has the propensity to eject debris from the side opposite the drill which needs to be prevented from falling into the Pump Room. Following the core drilling, three nozzles require installation without the need for personnel to enter the pump room. The nozzle locations are approx. 10-12 ft. above the floor and installing equipment via a manned entry is both hazardous and time consuming.

SOLUTION: Design, fabricate, test, and deploy a system that can prevent debris from entering the 242-A Evaporator Pump Room. After completion of coring, the new wall nozzles shall be installed remotely and positioned to the necessary alignment. All systems must negate the need for worker access into the Pump Room and all installations/removals can only use the pump room bridge crane and impact wrench.

Core Catcher Installation



Core Drilling



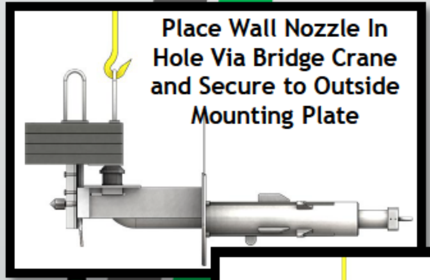
Core Catcher Removal

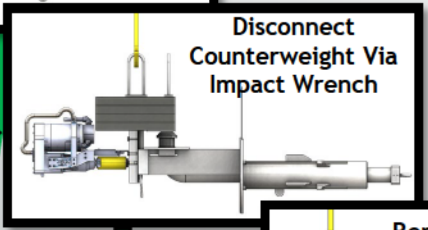
Tank Farm Projects Engineering | Year Developed - 2020 | Year Executed - 2021

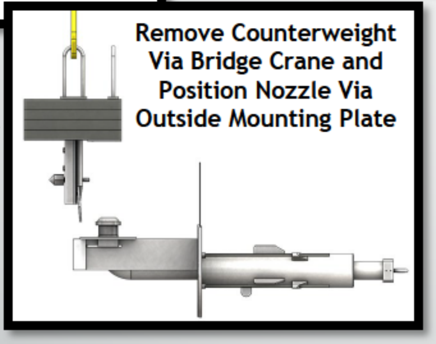
Pump Room Core Drilling and Wall Nozzle Installation Cont.

Tool suite which prevents workers from needing to enter highly contaminated 242-A Evaporator Pump Room

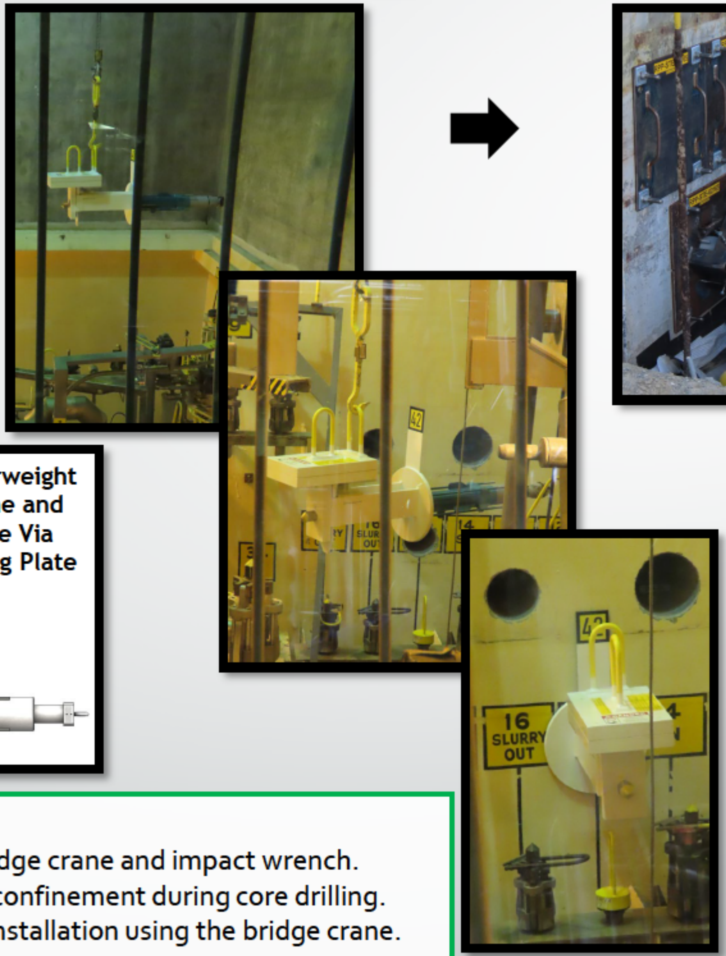
Wall Nozzle Installation Concept







Wall Nozzle Placement



Secure Nozzle / Remove Counterweight

Position Wall Nozzles for Grouting

INNOVATIVE FEATURES:

- Items can be installed using only the 242-A Evaporator bridge crane and impact wrench.
- Core Catcher is extended by impact wrench and provides confinement during core drilling.
- Nozzles feature a detachable counterweight to facilitate installation using the bridge crane.

IMPLEMENTATION HIGHLIGHTS:

- All the core drilling debris/slurry was captured by the Core Catcher leaving behind clean holes.
- All items were installed and functioned as intended the first time with no rework required.

Return on Investment = 3.5 | Hazard Mitigation = High | Estimated Dose Savings = 7.8 Person - Rem

Tools/Components Used:

- Core Catcher – RPP-STE-61951
- Core Drill Guide Assembly – RPP-STE-62165
- Nozzle Mounting Plate Assembly – RPP-STE-62165
- Wall Nozzle Assembly – H-14-111832

RD8200 Cable Locator Implementation

Reliable approach to identification of energized electrical obstructions

✓ INCREASED WORKER SAFETY | ✓ INCREASED TASK EFFICIENCY | ✓ COST REDUCTION

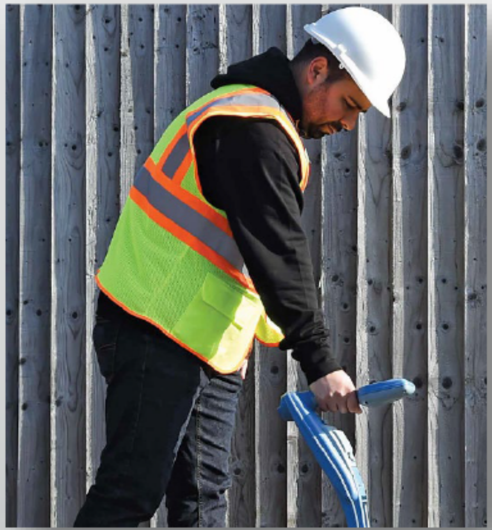
PROBLEM: AW Farm was built with direct buried electrical cables for power and instrumentation. Approximately 2-ft below grade, the spider web of cable make excavation difficult. The 242-A transfer line replacement project plans to excavate through the farm and needed a tool to accurately trace cables and properly identify the source to allow them to be deenergized. Current methods of tracing electrical cables were poor, utilized off-site vendors, and often resulted in schedule impacting troubleshooting efforts.

SOLUTION: Perform market research to identify tooling that could be used by field electricians and better isolate individual cables in congested areas. The Radio Detection RD8200 was identified as the best commercially available cable locator that has specific locating frequencies designed for use in congested areas. Purchase the device and train construction field electricians on its operation.

Market Research

→

Vendor Training



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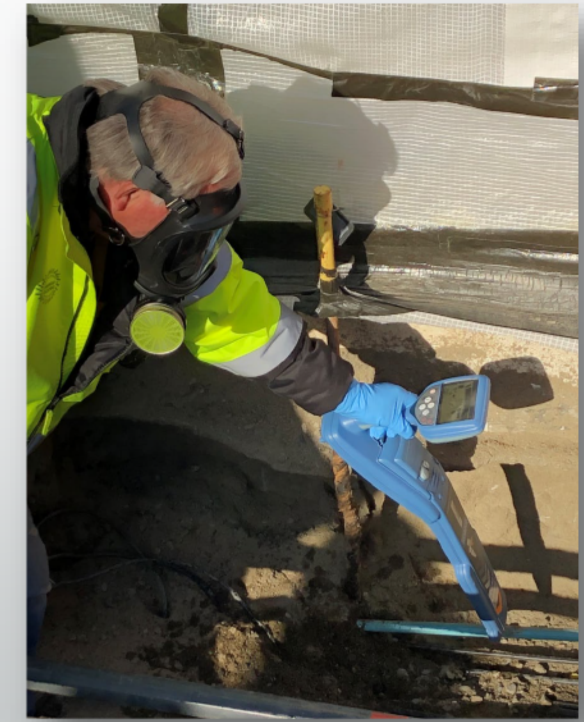
Field Implementation



INNOVATIVE FEATURES:

- Commercially available item that is easily purchased and user intuitive.

IMPLEMENTATION HIGHLIGHTS:

- Purchase of the RD8200 came with vendor training. Vendor was helpful and training was valuable.
- First time use resulted in the accurate identification and isolation of six energized cables in a trench with 40 cables in less than one shift.

Return on Investment = 2.3 | Hazard Mitigation = Moderate | Estimated Dose Savings = N/A

Lead Point of Contact - Matt Huntington | *Year Developed* - 2021 | *First Used* - 2021

Solid Sampler Retrieval System & Enhancements

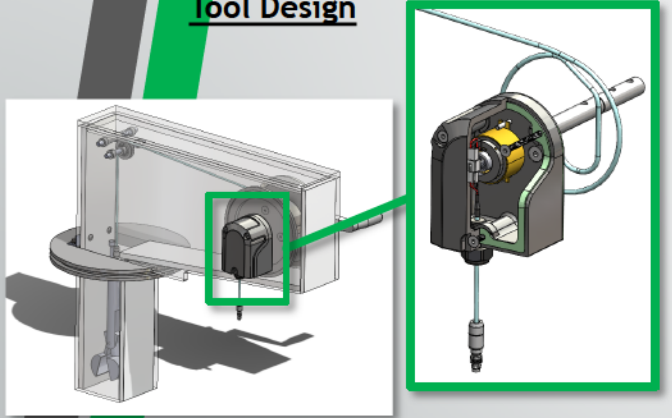
New solid sample retrieval system speeds up work evolution and reduces worker strain and dose

✓ NEW CAPABILITIES | ✓ INCREASED WORKER SAFETY | ✓ REDUCED WORKER DOSE | ✓ COST SAVINGS

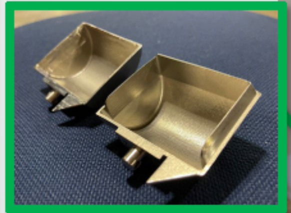
PROBLEM: The currently used RT-1000 (aka Clam Shell) solids sampling system has difficulty retaining collected sample material, often resulting in the need to make many grab attempts to obtain the desired sample volume. Additionally, the system is deployed by direct operator contact with the device in a non-ergonomic fashion. This creates both unnecessary dose uptake and worker strain/fatigue.

SOLUTION: Develop and deploy an enhanced sampling system that addresses current system inadequacies. The new system can be deployed from outside the containment area (glove-bag) from a self-supporting winch system. New scoops and control hardware were designed that offer higher solids retention and allow the system to operate faster. The new system modifies the existing stock of sampling devices in order to keep costs minimal.

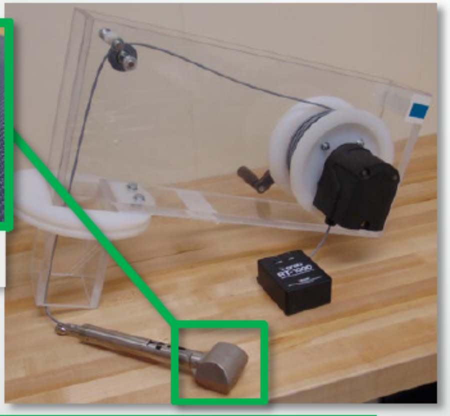
Tool Design



Fabrication and Testing



Enhanced Scoops



Simulant Testing w/ New Scoops

Field Implementation

Deploying the Solid Sampling Device

INNOVATIVE FEATURES:

- Revised control hardware improves system speed by 33% and sample retention by up to 42%
- System can be deployed/retrieved via a self-supporting winch system, reducing operator strain and dose

IMPLEMENTATION HIGHLIGHTS:

- Operators were able to raise/lower the sampler 13 times on a single deployment to collect troublesome material. This number of attempts was impossible with previous hardware and would have taken multiple days.
- Achieved outstanding dose reduction when combined with other long-reach tools and dose attenuation tools

Return on Investment = TBD* | Hazard Mitigation = High | Estimated Dose Savings = TBD* — * EVALUATION IN PROGRESS

Point of Contact - Peter Griffin | *Year Developed* - 2021 *Tool Evaluation* - RPP-STE-63172

Solid Sampling Support Equipment

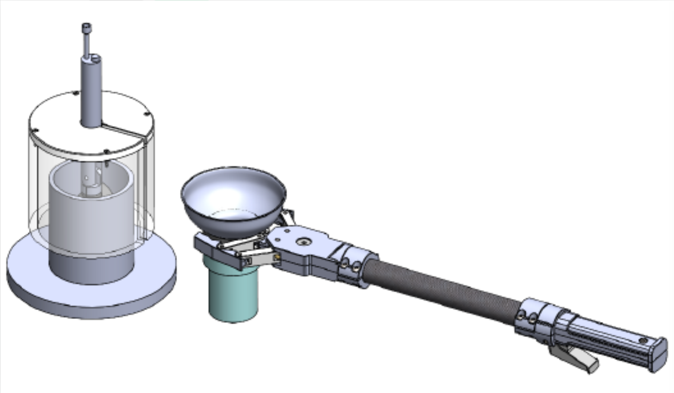
Low-cost, reliable remote handling and shielding equipment makes sampling extreme-dose waste possible

✓ NEW CAPABILITIES | ✓ INCREASED WORKER SAFETY | ✓ REDUCED WORKER DOSE | ✓ COST SAVINGS

PROBLEM: Solid sample collection requires numerous off the shelf components and tools that are not optimized to perform high-hazard work. This has resulted in sample spills and unnecessary dose uptake. No off-the-shelf tools have been identified that can adequately rectify these problems.

SOLUTION: Simplify solids sample collection and transfer between the retrieval device and sample bottle. Shield workers from the extreme dose expected during AX-104 sampling activites and streamline remote handling of sampling. Develop and deploy a stabilized funnel, beta-shield, and reliable long reach tool.

Tool Designs



Remote Handling Tool

INNOVATIVE FEATURES:

- The Remote Handling Tool and support equipment are specifically designed to reliably engage with each other, greatly reducing the probability of dropped or spilled samples.
- The long-reach tool is modular and can be easily modified to suit other applications
- The equipment is very low cost, making it a sustainable solution for all sampling jobs

IMPLEMENTATION HIGHLIGHTS:

- The beta shield and remote handling tool made sampling AX-104 possible via conventional means. Without the tools, the dose would have been too high for workers to sample and a significantly different approach or equipment would have been required.
- The Remote Handling Tool has now been adopted for use on other jobs as well

Field Implementation

Tool Deployment in Glove Bag at AX-104

Stabilized Funnel

RT-1000 Beta Shield

Return on Investment = TBD* | Hazard Mitigation = High | Estimated Dose Savings = TBD*

* EVALUATION IN PROGRESS

Point of Contact - Peter Griffin | *Year Developed* - 2021 | *Tool Evaluation* - RPP-STE-63173