1 of 2

Technology Development Activities Supporting Tank Waste Remediation

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Summary

This document summarizes work being conducted under the U.S. Department of Energy's Office of Technology Development (EM-50) in support of the Tank Waste Remediation System (TWRS) Program. The specific work activities are organized by the following categories: safety, characterization, retrieval, barriers, pretreatment, low-level waste, and high-level waste. In most cases, the activities presented here were identified as supporting tank remediation by EM-50 integrated program or integrated demonstration lead staff and the selections were further refined by contractor staff. Data sheets were prepared from DOE-HQ guidance to the field issued in September 1993. Activities were included if a significant portion of the work described provides technology potentially needed by TWRS; consequently, not all parts of each description necessarily support tank remediation.

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1.0 Introduction

1.1 Background

For over 40 years, the U.S. Department of Energy (DOE) produced nuclear weapons for national defense purposes. The DOE complex generated large quantities of hazardous and radioactive wastes stored in underground tanks at multiple sites in the United States, the largest quantities stored at Hanford.

The DOE, the Environmental Protection Agency (EPA), and the State of Washington recently negotiated a new strategy for remediation of wastes at the Hanford site. Successful implementation of the new Tank Waste Remediation System (TWRS) strategy will depend on the availability or development of technologies required. To help coordinate development of the necessary technology, Hanford formed the Technology Development Program Office (TDPO) to identify and coordinate technology development in support of the TWRS. As part of this role, activities supporting the TWRS, funded by the U.S. Department of Energy's (DOE's) Office of Environmental Restoration and Waste Management (EM), Office of Technology Development, are being identified. This document presents data sheets describing those activities, providing a resource for TWRS staff to help identify and interface with current Office of Technology Development (EM-50) activities that may support specific end user needs. The data sheets provided here are similar to those in a companion plan entitled *FY94 Tank Waste Remediation System: Technology Development Plan*. That document describes similar TWRS-sponsored activities under the Office of Waste Management (EM-30).

The data sheets presented in this document were generated jointly by TDPO and EM-50 staff as a means to describe activities conducted under the two programs in a consistent format. The data sheets will be revised as additional information becomes available, and more will be added as further activities supporting TWRS are identified.

1.2 Office of Technology Development

The Office of Technology Development (EM-50) was established in 1989 and tasked with carrying out an aggressive national program of applied research and development to focus, manage, and accelerate the field use of promising treatment technologies, particularly those that will meet specific environmental restoration and waste management requirements. The Technology Development Program objective is to respond to EM Program needs by developing and implementing technologies which

- facilitate compliance with applicable laws, regulations, and agreements
- minimize the generation of wastes

- clean up DOE sites at less cost than baseline technologies
- ensure that the technical work force is developed and retained to meet EM goals.

EM-50 includes a broad national program involving many contractors, vendors, universities, and government agencies focused on issues at a national level. The national program is divided into several functions related to the data sheets presented in subsequent chapters, including Research and Development; Demonstration, Testing, and Evaluation; Technology Integration; Special Programs, and Program Support. These functions are further organized into activities called Integrated Demonstrations (ID) and Integrated Programs (IP), also reflected in the data sheets.

1.3 Data Sources

The technology development data sheets in this document were developed through discussions with EM-50 staff, generally the Integrated Demonstration Coordinator (IDC) or the Integrated Program Coordinator (IPC). In most cases the activities presented were identified as supporting tank remediation by the IDC/IPC and the selections were further refined by TDPO/EM-50 staff. Information was received from each of the following EM-50 entities:

- Underground Storage Tank Integrated Demonstration (UST-ID)
- Robotic Technology Development Program (RTD)
- Efficient Separations and Processing Integrated Program (ESP-IP)
- VOCs in Arid Soils Integrated Demonstration (VOC Arid-ID)
- Mixed Waste Landfill Integrated Demonstration (MWL-ID)
- Characterization, Monitoring and Sensors Technology Integrated Program (CMST-IP)
- In Situ Remediation Integrated Program (ISR-IP)
- Buried Waste Integrated Demonstration (BW-ID)
- Minimum Additive Waste Stabilization (MAWS) Program
- Rocky Flats FFCA Compliance
- Mixed Waste Integrated Program (MW-IP)
- Supercritical Water Oxidation Program (SCWOP)
- Morgantown Energy Technology Center

Many of the EM-50 activities described on the data sheets currently receive direct support and involvement from EM-30 staff. A number of other current EM-50 activities are also included that were judged by the IDC/IPC or TDPO/EM-50 staff to be applicable to TWRS activities. The descriptions provided on the data sheets provide basic information about the technology; EM-30 staff are encouraged to contact the persons developing the technology for more information and/or to provide input regarding EM-30 needs for technology. Contact can be made through the contractor's EM-50 Technical Program Manager or from DOE at 1-800-845-2096.

In most cases, the data sheets were prepared from information contained in DOE-HQ guidance to the field issued during September 1993. Only activities underway in FY 1994 are included. The scope statement was adapted from the task summary section of the guidance; only those milestones that appear to be the most significant are shown. The FY 1994 funding level shown on the data sheet is that identified at the beginning of the fiscal year. In most cases it does not include carryover from the prior year or changes made after the beginning of the fiscal year. A representative of each ID/IP listed above has been asked to review the attached data sheets and their comments have been included. As is evident from the data sheets, the preparer has not yet been successful in obtaining some milestone and cost data.

Note that this description of EM-50 activities is only as current as the data source. For current information, please refer to the Technical Task Plans describing each activity.

1.4 Document Organization

The data sheets are organized by user category as shown below. Many of the technology development activities logically support more than one of the categories but for this first draft, each activity is shown only once in the primary area of application. Activities are included if a significant portion of the work described provides technology potentially needed by TWRS; consequently, not all parts of the descriptions support tank remediation. Table 1.1 summarizes EM-50 funding committed to each TWRS need category and performing organization. Tables showing the activity title, performing organization, and FY 1994 funding are located at the end of each chapter. The list below outlines the categories of technology development activities and briefly defines the technical needs driving each category.

- Safety
 - Mitigating and resolving safety issues
 - Improving instrumentation for monitoring tank waste
- Characterization
 - Developing the capability to acquire representative samples of solids, liquids and gases from multiple locations within the tanks
 - Developing hot cell nondestructive analysis for rapidly scanning chemical and radiological constituents of core samples

- Increasing capability for in situ measurements
- Improving methods for determining structural integrity
- Developing capability for identifying and assessing leaks
- Retrieval
 - Obtaining data to ensure the effective application of mixer pumps for double-shell tank retrieval
 - Developing low-water usage methods for removing wastes from single-shell tanks
 - Increasing capability to provide maintenance support
- Barriers
 - Developing methods to confine single-shell tanks leaks during storage or hydraulic sluicing waste retrieval
- Pretreatment
 - Destroying organic and ferrocyanide to resolve safety issues
 - Developing waste separations technologies for supernatant and salt cake constituents, such as solid-liquid separation and Cs, Tc ion exchange
 - Removing additional radionuclides and selected hazardous chemicals from the low-level waste (LLW) stream
 - Adequately developing solid waste dissolution and separations processes to select the extent of separations to be deployed
- Low-Level Waste
 - Developing a high-capacity vitrification system
 - Tailoring glass formulations for specific tank wastes and defining waste composition and processing parameters to ensure the waste form will meet performance specifications
 - Resolving uncertainties in the long-term behavior of LLW forms and engineered disposal system

- **High-Level Waste**
 - **Developing high-capacity melter systems to immobilize the higher waste volumes that would result from limited pretreatment of double- and single-shell tank waste**
 - **Developing feed preparation and melter offgas treatment systems**
 - **Defining and developing an optimized canister for the vitrified waste product.**

Table 1.1. TWRS EM-50 Technology Development Summary

	PNL	WHC	LANL	SNL	INEL	ORNL	BNL	LLNL	Ames	ANL	WSRC	Others	Total
Characterization	3050	7200	1485	2880	3996	2185		770	1454		825	552	24397
Retrieval	3050	400	160	5880	1795	480						2444	14209
Barriers	1335	1490		1920		500	1472				340	1771	8828
Pretreatment	4475	900	1750	1380	4680	4675				2350	2550	479	23239
HLW Vitrification					700								700
LLW Treatment	2150					2275	180			1740	2100	4933	13378
Total	14060	9990	3395	12060	11171	10115	1652	770	1454	4090	5815	10179	84751

2.0 Safety

Safety is the top priority activity requiring extensive analysis and evaluation prior to tank waste remediation. Due to the critical and short-term nature of this need, obtaining this information is the responsibility of EM-30. Although a number of EM-50 activities provide safety information, none have been identified whose main purpose is resolution of safety-related issues. Technology development resolving safety issues that is currently underway at Hanford is presented in the plan entitled *FY 1994 Tank Waste Remediation System: Technology Development Plan*.

3.0 Characterization

3.1 Underground Storage Tank Integrated Demonstration (UST-ID)

3.1.1 Characterization System Integration

Principal Investigator: S. Eberlein, WHC

Work Statement

This task coordinates characterization, surveillance and monitoring devices and methods for the UST-ID. Tank waste characterization needs are defined and the user's functions and requirements provided to technology developers. This task ensures that characterization devices are compatible with deployment devices. The following tasks will be accomplished:

- Work with developers of hot cell spectroscopy devices to transfer lessons learned to in situ sensor development.
- Work with LDUA to oversee development, integration, and testing of monitoring, surveillance, and in-tank characterization devices.
- Work with cone penetrometer developers to identify and communicate needs for deployable sensors.
- Develop needs-driven functions and requirements for tank waste depth profiling and physical parameter characterization sensors.
- Actively pursue the identification of new customer needs and applicable technologies.
- Contract with industry and academia to procure fiber optic radiation effects studies, in situ rheology measurement, and end effectors for physical parameter measurements and depth profiling.

FY 1994 Budget: \$1175K

Major Milestones:

• Provide integrated work plan - November 1993.• Provide integrated test plan for LDUA - February 28, 1994.• Provide functions and requirements for depth profiling and characterization - June 30, 1994.• Provide final characterization strategy document - August 30, 1994.

3.1.2 Waste Analysis: Laser Raman Spectrographic Sensing in Hot Cell

Principal Investigator: F. Reich, WHC

Work Statement

This activity will consist of the following:

- Provide test plans and (with EM-30 supported personnel) perform system optimization and testing of Raman and IR spectroscopy systems in a mock-up facility
- Provide Raman hot cell and IR cold test data to all other participants
- Contract to and work with Florida State University (T. Vickers, C. Mann \$25K capital, \$125K expense) to continue developing Raman analysis methods and spectral library, including spectra of real waste samples
- Interface with the Light Duty Utility Arm System to provide requirements for probe design to SR 132003
- Using probe design specifications from SR 132003, let contract to procure Raman probe end effector for light-duty utility arm (LDUA)
- Work with SR 132003, SF 211203 and RL 441001 to provide requirements for Raman and infrared (IR) probe design for cone penetrometer deployment.

FY 1994 Budget: \$650K

Major Milestones:

• Complete sources sought RFQ for LDUA Raman probe - March 31, 1994.• Demonstrate integrated-IR spectroscopy system in cold test facility - September 30, 1994.

3.1.3 Development and Validation of On-Line Process Monitoring Methods and Equipment

Principal Investigator: S. Mech, WHC

Work Statement

This task will initiate the development of on-line process monitoring methods and equipment specifically addressing the problems of tank waste retrieval and processing. This task defines customer needs, functions, and requirements to lay the groundwork for later development. In outyears, this task will provide a testbed facility and support test procedure development and testing of process monitoring methods and devices. Other activities include the following:

- Work with customers at Hanford (and other participating sites, where applicable) to identify on-line process monitoring needs, requirements, and data quality objectives in the area of chemical monitoring.
- Address separations and preprocessing, low- and high-level waste vitrification needs.
- Provide needs and requirements to SR 132003.

FY 1994 Budget: \$100K

Major Milestones:

• Provide report of needs areas for chemical monitoring - January 31, 1994.• Provide initial data quality objectives for on-line chemical monitoring - September 30, 1994.

3.1.4 Acoustic Emission Method to Locate Pipeline Leaks

Principal Investigator: C. Pepper and J. Hooyman, ORNL

Work Statement

This activity addresses the use of acoustic monitoring technology to detect and locate leaks in new, double-walled pipelines. The technology should be applicable to new pipelines being constructed for the transport, separation, and treatment of tank wastes. Leak detection and location in pipelines used for the transport of tank waste addresses safety and environmental issues. A validated leak detection system will allow progress in the transport of waste for separations and processing. Project staff will

- work with the EPA, the Navy, and Vista Research or another commercial partner to test acoustic technology for application to waste tank transport pipelines
- address issues of the length of pipeline over which the method will work, placement of acoustic sensors, whether pressurization of pipelines can be limited, and what the minimum detectable leak will be
- work with the EPA to use the existing test bed for this activity
- concentrate on the issue of instrumenting new pipelines, not old pipelines.

It is anticipated that half of the TTP funding should be provided to the commercial partner.

FY 1994 Budget: \$200K

Major Milestones:

• Report on sensor placement and long pipe monitoring - June 30, 1994.• Demonstrate prototype configuration - September 30, 1994.

3.1.5 Advanced Fiber Optic Spectroscopy for Inorganic Contaminants

Principal Investigator: T. Vess, LLNL

Work Statement

This task is part of a joint effort to develop, test, and implement spectroscopy systems and probes for hot cell operational use and in-tank deployment for chemical molecular species identification. Based on experience deploying fiber-optic-linked chemical sensors in cone penetrometers, the task will support the design and testing of a Raman fiber optic probe for an in-tank cone penetrometer. The task will also

- investigate the suitability of other chemical sensors for inclusion in an in-tank cone penetrometer
- investigate the suitability of hot cell remote Raman imaging for rapid screening of core samples
- compare accuracy, precision, reliability, and speed of remote Raman (probe in hot cell, but with distance of perhaps 2 feet to core) with contact Raman
- work with RL 421207, RL 441001, and SR 132003 to establish Raman design requirements for cone penetrometer deployment
- recommend configuration for such a system if it is determined to be feasible.

FY 1994 Budget: \$300K

Major Milestones:

• Report on remote versus contact Raman - May 31, 1994.• Report on other chemical sensors that may be deployed in tank - July 31, 1994.• Finalize conceptual design for cone penetrometer Raman probe - September 30, 1994.

3.1.6 Spectrometer System for Hanford In Situ Deployment (AOTF)

Principal Investigator: P. O'Rourke, WSRC

Work Statement

This task will involve the following:

- Design, provide, and support testing of an in-tank probe for fiber optic linked Raman spectroscopy and IR spectroscopy
- Work with AL 141022 to determine optimal probe configurations for radiation resistance
- Work with RL 421207 to test and validate probes in hot cell and to address customer need for online monitoring
- Initiate design and test of probes for Raman and IR sensing of molecular constituents of on-line processes.
- Place CRADA with Ciba-Geigy for process monitoring testing.

FY 1994 Budget: \$270K

Major Milestones:

• Report on recommended fiber optic design - April 30, 1994.• Complete baseline LDUA Raman probe design - June 30, 1994.• Complete initial online probe design - September 30, 1994.

3.1.7 System Lead for Light Duty Utility Arm System Development and Testing

Principal Investigator: B. Carteret, WHC

Work Statement

The UST-ID Light Duty Utility Arm (LDUA) system Lead has the responsibility to coordinate activities at Hanford and other DOE sites to develop and demonstrate a mobile, robotics system to deploy end effectors in underground waste storage tanks. The primary mission of this system will be to perform surveillance, inspection, and limited scale retrieval tasks in Hanford's single-shell tanks. Under this task, WHC will manage a contract with Spar Aerospace of Toronto, Canada to develop an advanced robotics system for this application. Other support equipment will be designed and tested by a team of subsystem cognizant engineers and by Principal Investigators under TTPs separately funded by the UST-ID. Facility modification and equipment setup to prepare a cold test facility at Hanford for testing and demonstrating the LDUA system is also provided under this task. The System Lead will act as the primary interface and point of contact for the LDUA system with end users, DOE customers, and performing organizations, and will promote transfer of the system technology for applications at other DOE sites. The system is planned to be delivered for cold testing and demonstration in spring of 1995. A hot demonstration of the system is planned for 1996 in a single-shell tank.

FY 1994 Budget: \$4,475K

Major Milestones:

- Initiate conceptual design review - November 30, 1993.
- Issue EM-50/EM-30 responsibility matrix - January 30, 1994.
- Initiate preliminary (25%) design review - March 30, 1994.
- Issue draft cold test plan - April 30, 1994.
- Conduct end effector and data acquisition system demonstration - June 30, 1994.
- Issue regulatory compliance strategy - June 30, 1994.
- Initiate final (80%) design review July 30, 1994.
- Issue revised system functions and requirements - September 30, 1994.

3.1.8 Computer Control Interface and Sensor Interface

Principal Investigator: B. Davies, B. Spletzer, SNL

Work Statement

Under Task 1, SNL is responsible for developing and qualifying an advanced (mission II) supervisory control system for LDUA manipulative control based on the SNL-developed Generic Intelligent System Controller (GISC) architecture. This supervisory control system will be implemented after fully qualifying the LDUA system with the Spar LDUA control system, and will provide advanced capabilities not provided by Spar. Establishing configuration management procedures and qualification of GISC software modules in compliance with the LDUA Software Development Plan will be a major task under this TTP. SNL will work with WHC and Spar Aerospace to develop an integrated control system architecture for controlling the robotics arm and deployment mast. SNL will develop the capabilities for generating a computer-based world model of the tank environment incorporating data input from various sources, including existing drawings and sensory data from various mapping and sensing end effector systems.

Under Task 2, SNL is responsible for developing and qualifying the supervisory data acquisition system for LDUA end effector control and data handling. This system will be based on the GISC architecture to allow data to be exchanged with the manipulative control system. This data acquisition system will gather, analyze, display, and archive information obtained from various sensor systems. The user interface will be developed using a commercial software package called Lab views. This data acquisition system will be demonstrated in FY 1994 at Hanford. This subtask also includes design, modification, and equipment installation for the LDUA Operations and Control Trailer to be delivered to Hanford in FY 1994. This trailer will be used as the operations station from which remote operation of the control and data acquisition systems will be conducted.

FY 1994 Budget: \$1680K

Major Milestones:

- Deliver 25% design review package to system lead - February 28, 1994.
- Demonstrate prototype control system user interface - February 28, 1994.
- Demonstrate data acquisition system at Hanford February 30, 1994.
- Complete validation and verification; release LDUA GISC kits - June 30, 1994.
- Deliver 80% design review package to system lead - June 30, 1994.
- Issue letter report on rad-hardened multiplexor - August 30, 1994.
- Ship LDUA trailer to Hanford - August 30, 1994.

3.1.9 Decontamination System and Surveillance End Effectors

Principal Investigator: B. Griebenow, INEL

Work Statement

INEL is responsible for providing decontamination system equipment for the LDUA Tank Riser Interface and Confinement (TRIC) subsystem. This equipment will be provided in an independent module to be interfaced with the TRIC enclosure (provided by Westinghouse Hanford Company) for testing at Hanford in the LDUA cold test facility. This system will use commercial pelletized carbon dioxide decontamination equipment with a special custom-designed nozzle configuration to decontaminate the mast, arm and end effectors as they are withdrawn from the tank riser. INEL will establish a Consolidated Research and Development Agreement (CRADA) with a commercial supplier to develop the specialized equipment required for the LDUA design configuration. INEL will work with their CRADA partner to evaluate the potential for using their commercial decontamination system ventilation unit to provide the ventilation for the TRIC subsystem. INEL will also provide a flexible and compliant tank riser interface module that will be mounted below the decontamination module. Under a second task, several surveillance and inspection end effectors will be developed for deployment by the LDUA robotics arm to perform non-destructive examination tasks. A third task will investigate the requirements for deployment of a LDUA system in INEL tanks and develop strategic plan and requirements documentation to support this mission.

FY 1994 Budget: \$900K

Major Milestones:

- Complete letter report on CRADA requirements - October 31, 1993.
- Complete decon system development test plan - December 30, 1993.
- Submit 25% design review package to system lead - February 28, 1994.
- Complete letter report on INEL LDUA deployment strategy - June 30, 1994.
- Submit 80% design review package to system lead - June 30, 1994.
- Demonstrate decontamination system at INEL - August 30, 1994.
- Provide functional requirements for INEL LDUA system - August 30, 1994.

3.1.10 Structured Light Topographical Mapping System

Principal Investigator: B. Burks, ORNL

Work Statement

ORNL is responsible for developing and fabricating a radiation-hardened structured light system and the required low level control hardware and software. This system will be used in conjunction with the LDUA system to perform topographical mapping of the tank interior. This task will include design and fabrication of tank interface hardware required to interface and mount the system on a 4" tank riser of a Hanford single-shell tank. A second task will demonstrate fusion of mapping data gathered by both a structured light system and a laser rangefinder system. This task will integrate the data from both systems into a standard format for delivery to the data acquisition system provided by SNL. The LDUA data acquisition system will use this fused data in creation of the tank world model for the supervisory control system. A demonstration of the structured light mapping system and data fusion will be provided as part of the FY 1994 demonstration at Hanford. A third task involves investigating the potential for using a LDUA system for waste heel removal from the ORNL tanks. A prototype sluicing end effector will be tested to investigate the design parameters that will be required to interface such an end effector with the SPAR LDUA design. A report on recommendations for pursuing a future deployment at ORNL, as well as functional requirements for such a system, will be provided.

FY 1994 Budget: \$850K

Major Milestones:

- Complete letter report describing data fusion strategy - November 30, 1994.
- Complete structured light test plan - December 30, 1994.
- Submit 25 % design review package to system lead - February 28, 1994.
- Demonstrate structured light/data fusion at Hanford - May 30, 1994.
- Submit 80 % design review package to system lead - June 30, 1994.
- Demonstrate candidate LDUA waste mobilization end effector - August 30, 1994.
- Provide functional requirements for ORNL LDUA system - August 30, 1994.

3.1.11 Technical Integration and Laser Rangefinder

Principal Investigator: C. Smith, PNL

Work Statement

PNL is responsible for providing a technical liaison to support the WHC contract with SPAR Aerospace to oversee the LDUA system design and testing. Under this task, the Principal Investigator will act as the Cognizant Engineer for the LDUA robotics arm and deployment system. This task will involve updating the LDUA system functional requirements and specification, reviewing technical progress of work by SPAR, reviewing SPAR manufacturing and test plans, and witnessing required hold point inspections at the vendor site. This task will also involve specifying requirements for packaging the LDUA end effectors for interface with the tool interface plate on the end of the robotics arm. A second task will involve organizing and conducting a demonstration in FY 1994 of the LDUA data acquisition system and selected surveillance and inspection end effectors. A third task provides for developing a laser rangefinder end effector and the required low level controls to interface with the SNL-provided data acquisition system. The laser rangefinder (LRF) will be used to perform topographical mapping of underground storage tanks interiors.

FY 1994 Budget: \$825K

Major Milestones:

- Submit draft LRF hardware evaluation plan - October 31, 1993.
- Submit 25% design review package to system lead - February 28, 1994.
- Conduct end effector/data acquisition system demonstration - June 30, 1994.
- Submit 80% design review package to system lead - June 30, 1994.
- Submit draft LRF procurement specification - September 30, 1994.

3.1.12 Surveillance and Inspection Systems

Principal Investigator: F. Heckendorn, WSRC

Work Statement

WSRC is responsible for design and fabrication of remote viewing systems for the LDUA System. This work will encompass development of systems for deployment by the LDUA robotics arm and also for independent deployment through 4" tank risers. Design and fabrication of appropriate tank interface and deployment equipment for installation on 4" tank risers is also included in the scope of work. WSRC will deliver several of these systems to Hanford in FY 1994 for testing and demonstration. The systems being provided include two end effector and two overview systems, which will provide both single and stereo vision capabilities.

FY 1994 Budget: \$350K

Major Milestones:

- Complete letter report on overview rad-hardened camera system - November 30, 1993.
- Complete remote viewing systems demonstration test plan - December 30, 1994.
- Submit 25% design review package to system lead - February 28, 1994.
- Demonstrate remote viewing systems at Hanford - May 30, 1994.
- Submit 80% design review package to system lead - June 30, 1994.
- Draft functional and operational requirements - August 30, 1994.

3.2 Characterization, Monitoring and Sensors Technology Integrated Program (CMST-IP)

3.2.1 Laser Ablation Mass Spectrometry Scanning of Waste Tank Core Sample

Principal Investigator: S. D. Colson, PNL

Work Statement

This task will fund development of molecular speciation analysis techniques as well as the development of data reduction and analysis techniques for analysis of waste tank core samples. It is a vital element of the overall Advanced Hot Cell Analytical Technology (AHCAT) project which will develop, demonstrate, and deploy equipment for using laser ablation mass spectrometry techniques to provide scanning analysis of chemical species present in waste tank core samples. As part of a joint WHC/PNL hot cell capabilities enhancement effort, the AHCAT project has been supported in FY 1993 by EM-30. This co-funding arrangement provides a mechanism for EM-50 to ensure customer acceptance and use of new technology systems. Successful completion of the AHCAT hot cell project will provide a capability for routine scanning along the length of cores to determine chemical concentrations as a function of distance along the core axis. The FY 1994 tasks are designed to complement work supported by EM-30.

FY 1994 Budget: \$425K

Major Milestones:

- Complete letter report for sampling in air - June 1, 1994.
- Obtain results of pattern recognition demonstration - August 1, 1994.
- Obtain data for safety analysis for hot cell deployment - September 30, 1994.
- Complete draft progress report - September 30, 1994.
- Establish criteria for candidate MS detection - September 30, 1994.

3.2.2 Transuranic and Moisture Measurement in High-Level Waste Tanks by Neutron Activation

Principal Investigator: R. L. Brodzinski, PNL

Work Statement

This task provides a copper sensor for measuring transuranic (TRU) waste and moisture content, addressing two driving safety needs for underground storage tanks. This task is a companion to a cone penetrometer deployment system capable of penetrating through most forms of waste to the bottom of the waste tank, RL442007. This package primarily addresses customer characterization and safety needs which cannot currently be met by any other known technology. This addresses the need to measure fissile material, generally concentrated at the tank bottom. Core sampling methods do not recover the bottom 3 inches of waste material, but the cone penetrometer/copper combination will access this area.

A copper probe for measuring neutrons and moisture will be provided. This task provides funding for manufacturing a prototype probe, assembling a calibration mock-up facility, and initiating the technique calibration.

FY 1994 Budget: \$300K

Major Milestones:

- Complete copper sensor fabrication - February 1, 1994.
- Complete design and assembly of mock-up calibration facility - June 1, 1994.
- Provide draft report of calibration activities - July 1, 1994.

3.2.3 Electromagnetic Moisture Measurement in Single-Shell Tank Waste

Principal Investigator: R. Hockey, PNL

Work Statement

The objective of this 2-year project is to develop an electromagnetic induction method for measuring the moisture content and liquid water level in single-shell tank (SST) waste. This project will involve electrical property measurements of waste tank simulants having known moisture content as well as core samples of high-level waste (HLW) SSTs. A series of experiments will be performed on simulants to determine if a single relationship exists between induction coil impedance and the concentration of water in the simulant. The physical and chemical properties of the waste matrix that may affect this relationship, with particular emphasis on the sensitivity of the impedance measurement to the composition and temperature of the waste, will also be investigated in a second series of experiments. A third set of experiments, conducted on actual core samples, will determine if the electrical properties of these samples are similar to those properties in investigated simulants. These experiments will also determine the range of depths that electromagnetic waves can penetrate when an electromagnetic coil is placed in SST waste by measuring the electrical properties of core samples archived in a hot cell. Further simulant formulations will be developed and tested if significant discrepancies between simulant and tank waste electrical properties are observed. If laboratory tests of this method are shown to satisfy SST moisture measurement needs, a small-scale measurement system will be developed and evaluated for accuracy, precision, and range of moisture and water level measurement under waste tank conditions.

FY 1994 Budget: \$475K

Major Milestones:

- Complete electromagnetic measurements with simulants - November 26, 1993.
- Status update on the search for a suitable industrial partner - February 10, 1994.
- Measure core sample electrical properties - February 15, 1994.
- Complete calibration with simulants and determine critical distance of measurement - March 23, 1994.
- Complete FY 1994 Report - September 30, 1994.

3.2.4 Imaging Through Obscuration for Sluicing

Principal Investigator: T. Peters, PNL

Work Statement

This task addresses issues involved in providing visual surveillance capability in tanks while performing sluicing operations. Sluicing will cause mists, fog, or airborne particulates to obscure the imaging capabilities of standard cameras. This task will also

- review potential methods for imaging through obscuration. Work with customers to determine likely conditions and best candidates for further development
- provide a test chamber to evaluate methods, working with customers to ensure suitability of design
- evaluate available methods. Use existing equipment and/or work with commercial vendors willing to loan equipment for demonstration.

FY 1994 Budget: \$175K

Major Milestones:

- Complete review of current state-of-the-art methods for viewing through obscurations - April 1, 1994.
- Complete test of selected methods under various conditions in the chamber - May 15, 1994.
- Complete final report - July 1, 1994.

3.2.5 Cone Penetrometer for In Situ Waste Tank Characterization

Principal Investigator: L. Bunes, WHC

Work Statement

This task provides a cone penetrometer deployment system capable of penetrating most forms of waste to the bottom of the waste tank. The cone penetrometer can deploy a variety of sensors and determine several physical properties of the waste. A companion TTP provides a copper foil sensor for measuring TRU waste and moisture content, addressing two safety needs. Related tasks in TTPs SF211203 and RL401206 to design a Raman spectroscopy sensor to be deployed with the penetrometer address additional safety needs and provide chemical characterization information to support process planning.

This task will provide an enhanced cone penetrometer capable of deploying a sensor package at depth in a waste tank, penetrating a variety of materials including solid waste layers. In FY 1994, this task will determine the needs, functions, operational, and interface requirements. This information will be provided as the basis for a commercial contract to provide a conceptual design, test the design, and provide a detailed design for constructing a cone penetrometer capable of penetrating hard waste. The actual construction of the penetrometer (as a commercial contract) will take place in FY 1995, if the testing and design conducted in FY 1994 indicate the system will be successful.

FY 1994 Budget: \$800K

Major Milestones:

- Define system needs and requirements - December 1, 1993.
- Contract in-place for concept design and testing - January 1, 1994.
- Complete analysis and testing of design - September 1, 1994.
- Determine whether or not to proceed with construction - September 30, 1994.

3.2.6 Effects of Gamma Irradiation on a Fiber Optic-Based Raman Probe

Principal Investigator: R. J. Donohoe, LANL

Work Statement

This TTP is part of a joint effort to develop and test spectroscopy systems and probes for hot cell operational use, and for in-tank deployment to identify chemical molecular species. The FY 1994 work will concentrate on commercially available probes and components.

The following tasks will be accomplished:

- Work with SR132003 to acquire and test all components of Raman probes in radiation fields.
- Evaluate the effect of probe irradiation on total system performance.
- Recommend optimal configurations for probe survival.
- Coordinate activities and results with SR132003 (and subcontractors NRL and USC) and RL401206.

FY 1994 Budget: \$150K

Major Milestones:

- Provide initial report - March 31, 1994.
- Complete engineering of fiber-optic-based probe within gamma field - September 30, 1994.
- Complete evaluation of commercial probe response to radiation exposures - September 30, 1994.
- Provide final report - September 30, 1994.

3.2.7 Problem-Directed Rapid Chemical Characterization

Principal Investigator: R. Jenkins, ORNL

Work Statement

The purpose of this effort is to develop the capabilities for the rapid identification of unknown organic chemical releases to the occupational and ambient environment. This involves assembling currently available technologies for rapid response, and developing and validating sampling and characterization instrumentation and methods applicable to specific ER/WM issues. Spills and air-borne releases receive particular attention. During FY 1994, the principal activities to be conducted under this TTP include the following:

- Developing a split vent/archival sampling system for non-ion trap analytical technologies
- Consulting with affected sites regarding the most appropriate sampling systems for fugitive releases
- Rapidly responding to characterization needs associated with fugitive releases.

This task provides access to the multiple chromatographic and spectroscopic identification resources of the Analytical Chemistry Division of ORNL. The principal cost savings resulting from this project are associated with the reduction in response times to off-normal occurrences, and increases in the confidence with which accurate characterizations can be made.

FY 1994 Budget: \$100K

Major Milestones:

• Complete prototype split vent sample archival system for non-DSITMS system - June 30, 1994.• Complete letter report on rapid characterization activities - September 30, 1994.

3.2.8 Sensing of Head Space Gases and Continuous In Situ Monitoring

Principal Investigator: G. J. Bastiaans, Ames

Work Statement

This task will develop miniaturized, field-deployable gas sensors for use in the in situ monitoring of head space gases in underground storage tanks (USTs) and at other remediation sites. The head spaces of USTs contain explosive and toxic gases such as hydrogen, nitrous oxides, hydrocarbons, and ammonia. Safe maintenance and remediation requires a delineation of the evolution and diffusion of such gases within the USTs. Just as important, the levels of these gases must be monitored continuously for long periods of time at many different UST sites. Currently, head space gases are analyzed using expensive, sophisticated chromatography-mass spectroscopy instrumentation that requires skilled operators. A clear need exists for a simplified, cost-effective method to reliably characterize the head space gases in USTs.

This task will develop low-cost piezoelectric mass sensors, sensor arrays, and electronic readout instrumentation for determining the concentrations of several gases in the hostile environment of USTs. Using integrated circuit technology and specially developed sensor surface coatings, small sensor systems capable of long-term, low-maintenance operation will be fabricated as manufacturable prototypes and field tested to determine operational specifications.

FY 1994 Budget: \$619K

Major Milestones:

- Complete prototype of rad-hard ICs (key) - June 30, 1994.
- Submit 1994 technology transfer report - September 30, 1994.
- Identify technology transfer partner - September 30, 1994.
- Complete evaluation of initial field test data (key) - September 30, 1994.

3.2.9 Acoustic Characterization of Wastes in Stabilized Underground Storage Tanks

Principal Investigator: D. M. Martin, Ames

Work Statement:

The task will include four major areas: adapting existing acoustic sounding technology to be robust in the tank environment; developing a mechanism for coupling an acoustic probe to the salt cake and sludge layers; evaluating the acoustic properties of the various tank waste forms, which is crucial to effective use of acoustic methods in addition to addressing the need for characterizing the tank contents; and developing the best data acquisition and processing schemes from which three dimensional maps of tank contents can be made. The best effort will be made to construct a prototype system for field use. In the final demonstration a probe assembly with a remote instrumentation system for data acquisition and control will be installed in a tank, with training and operations documentation for the use of field technicians. Additional potential uses for the system will include focused local inspection in areas of interest inside tanks, and monitoring of stirring operations during pump out by acoustic location of sludge fluid interfaces.

FY 1994 Budget: \$300K

Milestones:

- Determine feasibility of acoustic technique in waste tanks - January 31, 1994.
- Submit detailed commercialization plan - February 10, 1994.
- Deliver acoustic probe designs to transducer manufactures - February 28, 1994.
- Complete data acquisition scheme - August 30, 1994.
- Deliver FY 1994 status report - September 30, 1994.

3.2.10 In Tank Interface Detection Using Time Domain Reflectrometry

Principal Investigator: H. R. Tilley, WSRC

Work Statement

Evaluate time-domain reflectrometry for use in high-level waste tanks. The primary criteria for success is the identification of interstitial fluid levels to ± 0.25 ". Simulants of high-level waste will be used for testing and evaluation in a laboratory environment. NOTE: The primary criteria for success for Phase I (Aug-Sep 1993) is determining thickness and interfaces between 1) organic layer and water, 2) water and air, and 3) interstitial fluid level in saturated sludge. Accuracy must be within 0.25". Secondary criteria for success will be the ability to measure moisture to within $\pm 5.0\%$ in the range of 0-50% moisture.

FY 1994 Budget: \$205K

Major Milestones:

- Design and fabricate probes - December 1, 1993.
- Test probe in simulant - December 15, 1993.
- Complete interim report - February 1, 1994.
- Complete additional system tests - May 1, 1994.
- Complete final report - June 1, 1994.

3.2.11 Resource Conservation and Recovery Act (RCRA) Metals Analysis by Laser-Induced Breakdown Spectroscopy

Principal Investigator: A. Koskelo, LANL

Work Statement

This task will develop field-deployable instrumentation for rapidly determining the RCRA metals content in soils, sludges, and exhumed materials at hazardous and mixed waste sites.

The technique is based on laser-induced breakdown spectroscopy. With this method, powerful laser pulses are focused on a material to generate a small microplasma or laser spark. Atomic emissions are identified by their unique spectral "fingerprints."

FY 1994 Budget: \$450K

Major Milestones:

- Complete proof-of-principle test on known samples - March 30, 1994.
- Evaluate figures-of-merit for fiber optic LIBS apparatus - September 30, 1994.
- Determine whether or not to proceed with construct of instrument - December 16, 1994.

3.2.12 Infrared Analysis of Wastes

Principal Investigator: J. McClelland, Ames

Work Statement

The project will develop the methodology for the quantitative analysis of molecular and multi-atom ionic species in the tank sludges and solids at Hanford via Fourier-transform infrared photo-acoustic spectroscopy (PAS). Such species are of special interest because of their chemical reactivity.

Once the methodology for producing quantitative spectra has been worked out, a training session will be held at Hanford by Ames personnel. The FTIR-PAS instrumentation, the quantitative methodology, and as much of the information on special dependence on composition that is determined will be transferred to Hanford personnel at that time. The spectral dependence on composition will then continue to be studied, and the results transferred to Hanford as they become available. An automatic sampling and shuttle system for use in hot areas will also be developed and installed at Hanford.

FY 1994 Budget: \$300K

Major Milestones:

- Establish methods for acquiring quantitative spectra - November 30, 1993.
- Complete FTIR-PAS installation and training sessions at Hanford - January 31, 1994.

3.2.13 Electrical Resistance Tomography for Subsurface Imaging

Principal Investigator: W. Daily, A. Ramirez, LLNL

Work Statement

Electrical resistivity tomography (ERT) provides a method for detecting and imaging moisture in the subsurface. The technology has been successfully demonstrated in the field. This project has two major subtasks: 1) provide funding to Lawrence Livermore National Labs for technology transfer to a company called RIMTech through an existing CRADA. The project will include two field demonstrations that will help train RIMTech in use of the instrumentation software and hardware, troubleshooting instrumentation or geophysical data anomalies, interpreting data, and understanding modeling. A full 3-D modeling code will be benchmarked. All software and models will be transferred to RIMTech; and 2) arrange for LLNL to work directly with tank surveillance personnel at the Hanford site to design and perform a feasibility test of ERT for tank leak detection at a Hanford testbed. The testbed will be provided by EM-30.

FY 1994 Budget: \$470K

Major Milestones:

- Complete testbed experiment design and test plan - December 1, 1993.
- Complete installation of equipment and initiate tests - May 31, 1994.
- Complete data analysis and provide report - September 30, 1994.

3.3 Robotics Integrated Program

3.3.1 Contaminant Analysis Automation

Principal Investigator: M. G. Dodson, PNL

Work Statement

The Contaminant Analysis Automation (CAA) program is focused on the timely design and implementation of automated chemical analysis systems to support the DOE remediation program. In FY 1993, a Systems Integrator role was identified and negotiations for a CRADA were initiated by LANL. The result of this work in FY 1994 will be a CRADA as signed by DOE with Lockheed Corporation, placing Lockheed in the position of performing the systems integration for commercial equipment as well as assisting DOE in selecting commercial vendors for Standard Laboratory Module (SLM) manufacture.

In coordination with other laboratories and sites, PNL will develop automated standard laboratory models (SLMs) for demonstration and deployment. Each module will have generic functions that, once developed, can be reapplied to many applications. Interfaces between elements will be standardized to promote multiple use and enhance integration of efforts by multiple developers.

The PNL scope of work is as follows: 1) build and demonstrate SLMs based on the experience gained thus far in the program, 2) support the cost/benefit Analysis for the CAA program. This will be accomplished using standard analysis methods as well as implementing the expert systems to develop optimizations of automated benches, and 3) co-develop a graphic user interface (GUI) to function as the top level interaction interface. The chemists will control the equipment using an interface that has been "human-factored" to their specific domain.

FY 1994 Budget: \$850K

Major Milestones:

- Complete digestion sample preparation SLM - March 31, 1994.
- Complete prototypical hot plate digestion SLM - September 30, 1994.
- Complete internal code for all PNL SLMs - September 30, 1994.

3.3.2 Robotics Contaminant Analysis Automation—SNL

Principal Investigator: R. W. Harrigan, SNL

Work Statement

This activity will consist of the following:

- To prepare for validation, test the actual lab operation of Standard Laboratory Modules (SLMs) for EPA Methods 3015, 3520, and 3051; modify hardware/software as necessary; retest; and document results.
- Complete a laboratory chemical validation of existing SLMs by processing real-world samples. Criteria will be based on the EPA Solid Waste 846 Methods and the DOE methods Performance Rating Scheme.
- Design, procure hardware, and fabricate SLMs necessary to complete prototypical SPMs for frequently used EPA methods.
- Integrate software and hardware SLMs and SSMs to complete a reliable plug-and-play sample analysis system.
- Provide DOE in-kind resources to support the Lockheed CRADA ensuring CAA technology transfer.

FY 1994 Budget: \$700K

Major Milestones:

• Finish SAM task sequence controller - March 31, 1994.• Refine, enhance, and integrate SAM user interface-database - March 31, 1994.• Finish supplemental documentation of hardware and software standards - September 30, 1994.

3.3.3 Robotics Contaminant Analysis Automation—WINCO

Principal Investigator: B. Wilding, INEL

Work Statement

This activity will consist of the following:

- To prepare for validation, test actual lab operation of Standard Laboratory Modules (SLMs) for EPA Methods 3015, 3520, and 3051; modify hardware/software as necessary; retest; and document results.
- Complete a laboratory chemical validation of existing SLMs by processing real-world samples. Criteria will be based on the EPA Solid Waste 846 Methods and the DOE Methods Performance Rating Scheme.
- Design, procure hardware, and fabricate SLMs necessary to complete prototypical SPMs for frequently used EPA methods.
- Integrate software and hardware SLMs and SSMs to complete a reliable plug-and-play sample analysis system.
- Provide DOE in-kind resources to support the Lockheed CRADA to ensure CAA technology transfer.

FY 1994 Budget: \$1300K

Major Milestones:

- Finish lab testing and modification of concentration SLM - March 31, 1993.
- Design/construct prototypic SLM for TCLP extraction - September 30, 1994.
- Develop internal control code for SLM - September 30, 1994.
- Complete supplemental documentation of hardware and software standards - September 30, 1994.

3.3.4 Robotics Contaminant Analysis Automation—ORNL

Principal Investigator: W. Hamel, ORNL

Work Statement: To be identified

FY 1994 Budget: \$1035K

Major Milestones:

- Finish construction of prototypical radionuclide plating SLM - June 30, 1994.
- Finish construction of prototypical alpha-counting SLM - September 30, 1994.
- Demonstrate mobile EPA 3540/3550 SAM system with robot SSM - September 30, 1994.

3.3.5 Robotics Contaminant Analysis Automation - LANL

Principal Investigator: R. M. Hollen, LANL

Work Statement

Under this activity, testing and modification of existing SLMs will be performed in preparation for validation; testing of actual lab operation of SLMs for EPA Methods 3015, 3520, and 3051; modification of hardware/software; retesting; and documentation of results. SLM Chemical Validation will be performed by processing real-world samples. Criteria will be based on the EPA Solid Waste 846 Methods and the DOE Methods Performance Rating Scheme. Development of priority SLMs will be performed by designing, procuring hardware, and fabricating SLMs necessary to complete prototypical SPMs for frequently used EPA methods. SAM System Integration will be performed by integration of software and hardware SLMs and SSMS to complete a reliable plug-and-play sample analysis system. Support Systems Integrator SAM Commercialization will provide DOE in-kind resources to support the Lockheed CRADA, ensuring CAA technology transfer.

FY 1994 Budget: \$485K

Major Milestones:

- Finish phase II of market analysis - December 31, 1993.
- Demonstrate mobile EPA 3540/3550 SAM system - March 31, 1994.
- Lead user interface/database development for SAM system integration - September 30, 1994.

3.4 Mixed Waste Integrated Program (MW-IP)

3.4.1 Continuous Monitor Using Tunable Diode Lasers to Measure NH₃

Principal Investigator: D. Ottesen, SNL

Work Statement

This project will develop and demonstrate near-infrared tunable diode laser spectroscopy as a continuous monitor for trace amounts of compounds in the effluent gases generated by DOE hazardous and mixed waste treatment processes. The demonstration instruments will be manufactured by PSI Environmental. The following tasks and subtasks will be carried out to complete this project:

- construct, field test, and deliver an ammonia monitor (\$200K);
- perform, employing existing equipment, proof-of-concept experiments on a halogen/sulfur species monitor (\$65K);
- identify performance specifications and instrument configuration for VOC monitor (\$65K); and
- construct and test a lab-scale VOC emissions monitor. Based on lab results, decide whether or not to construct a field unit (\$170K).

FY 1994 Budget: \$500K

Major Milestones:

• Deliver ammonia monitor - March 31, 1994.• Complete report on halogen/sulfur species proof-of-concept studies - July 30, 1994.• Test VOC lab-scale monitor - September 30, 1994.• Complete final report - September 30, 1994.

3.4.2 Development of a Real-Time Monitor for Airborne Alpha Emissions

Principal Investigator: R. E. Gritzo, LANL

Work Statement

This TTP plans to provide an instrument for monitoring emissions in a real-time, continuous, on-line manner for low levels of alpha-emitting radionuclides. This instrument will provide an order of magnitude or more improvement in sensitivity over current best available technology. The proof of concept and laboratory scale testing has been completed. The tasks to carry out this project are as follows: 1) identify and secure an industrial partner for the technology, 2) design full scale detector, 3) fabricate and bench test full-scale detector, 4) perform validation experiments on full-scale alpha detector, and 5) evaluate results and write final report.

FY 1994 Budget: \$400K

Major Milestones:

- Identify industrial partner - December 31, 1993.
- Complete fabrication and bench-scale testing - March 31, 1994.
- Determine demonstration site - August 31, 1994.
- Complete final report - September 30, 1994.

3.5 Buried Waste Integrated Demonstration (BW-ID)

3.5.1 Electrothermal Hollow Cathode

Principal Investigator: S. Weeks, Ames

Work Statement

This activity will develop and test a field Electrothermal Hollow Cathode Discharge Spectrometry (ET-HCDS) instrument in FY 1994. The instrument's applicability for determining actinides and their isotopes, including plutonium, shall be demonstrated at Ames laboratory facilities. Field testing and demonstration will be conducted at INEL in FY 1994 and FY 1995 in conjunction with other BW-ID characterization and retrieval technology demonstrations. Technology transfer opportunities also will be actively sought.

FY 1994 Budget: \$235K

Major Milestones:

- Complete test plan - March 31, 1994.
- Complete report on actinide analysis technology readiness - April 30, 1994.
- Complete field demonstration evaluation report - September 30, 1994.
- Complete analytical method report - September 30, 1994.

3.5.2 Preparation of Rapid Transuranic Monitoring Lab for Field Deployment

Principal Investigator: C. W. Sill, INEL

Work Statement

The scope of the FY 1994 effort is to complete the mobile Rapid Transuranic (TRU) Monitoring Laboratory (RTML) for ER and WM application. Upon completion of this task, the RTML will be transferred to ER/WM. The following subtasks will be performed:

- Incorporate a rapid, non-chemical analysis technology for screening beta emitters such as Sr-90 at the 50-pCi/g level
- Publish information regarding the RTML equipment and capabilities
- Develop and test alpha spectrum analysis techniques.

FY 1994 Budget: \$696K

Major Milestones:

- Complete testing of alpha spectrum analysis codes - March 20, 1994.
- Complete testing of beta spectrometer - July 1, 1994.
- Complete testing of LXRAY code - July 1, 1994.
- Complete final report on RTML - September 30, 1994.

3.5.3 Virtual Environment Generation of Buried Waste

Principal Investigator: T. Larson, INEL

Work Statement

This activity will investigate the feasibility and usefulness of the simulation-based planning and design concept for restoring subsurface hazardous waste sites. Available characterization data from actual and simulated waste sites at the INEL will be used to generate a virtual environment representing that site. An assessment of the usefulness of the virtual environment in remedial investigation, feasibility, and design will be conducted. This study will determine the characterization data features necessary to facilitate the generation of virtual environments and determine the methods, algorithms, and tools to assist in translating characterization information to a useful product. A prototype virtual environment of the INEL Cold Test Pit will be constructed. This prototype will assist in defining end user needs and requirements.

FY 1994 Budget: \$1100K

Major Milestones:

- Draft requirements generation and definition report - January 15, 1994.
- Finalize cost sharing/CRADA agreements - April 1, 1994.
- Draft FY 1994 technology evaluation report - September 30, 1994.

3.6 Technology Development Partnerships

3.6.1 Field Raman Spectrograph

Principal Investigator: M. M. Carrabba, EIC, Inc.

Work Statement

A field-hardened Raman spectrograph has been designed that can be used to obtain "chemical fingerprints" of concentrated and dilute hazardous waste contaminants in storage tanks, soil, and water. The instrument is a portable, small, analytical device capable of in situ measurements that can identify compounds up to 50 meters away from the spectrometer via fiber optic probes. The system is suitable for detecting highly concentrated materials and, with specially designed probes, for parts-per-billion levels.

FY 1994 Budget: \$552K

Major Milestones:

- Analysis of mixtures and establishment of Raman Spectra catalog - February 1, 1994.
- In situ chemical characterization - February 28, 1994.
- Phase I report - March 28, 1994.
- DOE decision to proceed with Phase II - March 28, 1994.

3.7 Activity Table

Table 3.1 lists the planned activities and budgets for the characterization activities.

Table 3.1. Activities Related to TWRS - Characterization

	Performing Organization	Budget
Underground Storage Tank Integrated Demonstration (UST-ID)		
Characterization System Integration	WHC	1175
Waste Analysis: Laser Raman Spectrographic Sensing in Hot Cell	WHC	650
Development and Validation of On-Line Process Monitoring		
Methods and Equipment	WHC	100
Acoustic Emission Method To Locate Pipeline Leaks	ORNL	200
Advanced Fiber Optic Spectroscopy for Inorganic Contaminants	LLNL	300
Spectrometer System for Hanford In-Situ Deployment (AOTF)	WSRC	270
System Lead for Light Duty Utility Arm System Development and Testing	WHC	4475
Computer Control Interface and Sensor Interface	SNL	1680
Decontamination System and Surveillance End Effectors	INEL	900
Structured Light Topographical Mapping System	ORNL	850
Technical Integration and Laser Rangefinder	PNL	825
Surveillance and Inspection Systems	WSRC	350
		<u>11775</u>
Characterization, Monitoring and Sensors Technology Intergrated Program (CMST-IP)		
Laser Ablation Mass Spectrometry Scanning of		
Waste Tank Core Sample	PNL	425
Transuranic and Moisture Measurement in High-Level		
Waste Tanks by Neutron Activation	PNL	300
Electromagnetic Moisture Measurement in Single Shell Tank Waste	PNL	475
Imaging Through Obscuration for Sluicing	PNL	175
Cone Penetrometer for In-Situ Waste Tank Characterization	WHC	800
Effects of Gamma Irradiation on a Fiber Optic Based Raman Probe	LANL	150
Problem-Directed Rapid Chemical Characterization	ORNL	100
Sensing of Head Space Gases & Continuous In-Situ Monitoring	Ames	619
Acoustic Characterization of Wastes in Stabilized USTs	Ames	300
In Tank Interface Detection Using Time Domain Reflectometry	WSRC	205
Resource Conservation and Recovery Act (RCRA) Metals Analysis by Laser-Induced Breakdown Spectroscopy	LANL	450
Infrared Analysis of Wastes	Ames	300
Electrical Resistance Tomography for Subsurface Imaging	LLNL	470
		<u>4769</u>

Table 3.1. (contd)

	Performing Organization	Budget
Robotics Integrated Program		
Contaminant Analysis Automation	PNL	850
Robotics Contaminant Analysis Automation	SNL	700
Robotics Contaminant Analysis Automation	INEL	1300
Robotics Contaminant Analysis Automation	ORNL	1035
Robotics Contaminant Analysis Automation	LANL	485
		<u>4370</u>
Mixed Waste Integrated Program (MWIP)		
Continuous Monitor Using Tunable Diode Lasers to Measure NH ₃	SNL	500
Development of Real-Time Monitor for Airborne Alpha Emissions	LANL	400
		<u>900</u>
Buried Waste Integrated Demonstration (BWID)		
Electrothermal Hollow Cathode	Ames	235
Preparation of Rapid Transuranic Monitoring Lab for Field Deployment	INEL	696
Virtual Environment Generation of Buried Waste	INEL	1100
		<u>2031</u>
Technology Development Partnerships		
Field Raman Spectrograph	EIC, Inc	552
		<u>552</u>
EM-50 Characterization Total		<u>24397</u>
Subtotals		
	PNL	3050
	WHC	7200
	ORNL	2185
	SNL	2880
	LANL	1485
	INEL	3996
	LLNL	770
	WSRC	825
	Ames	1454
	Others	552
Balanced Total		<u>24397</u>

4.0 Retrieval

4.1 Underground Storage Tank Integrated Demonstration (UST-ID)

4.1.1 Simulant Development

Principal Investigator: G. Golcar, PNL

Work Statement

This activity will identify appropriate tank waste simulants for use in each of the tank retrieval testing activities. Other activities include providing input for characterization activities, coordinating data, and developing proper simulants and preparation methods to ensure that testing is proceeding on a consistent and realistic basis. British Nuclear Fuels, Ltd. (BNFL, OR132008) will be consulted to share data.

FY 1994 Budget: \$100K

Major Milestones:

- Establish initial large-scale simulant fields - May 1994.
- Complete test results summary report - September 1994.

4.1.2 Waste Dislodging and Conveyance Mechanics

Principal Investigator: J. Bamberger, PNL

Work Statement

This activity will include work to define and evaluate parametric factors governing waste dislodging and conveyance methods. The 336 Building test facility will be installed and started for use in testing pneumatic conveyance and high-pressure dislodging methods singly and as a system.

FY 1994 Budget: \$800K

Major Milestones:

- Complete multi-year testing strategy document/test plan - April 1994.
- Document FY 1994 test results - September 1994.

4.1.3 Test Requirements and Evaluation

Principal Investigator: M. Rinker, PNL

Work Statement

This activity will provide system lead responsibilities to coordinate testing performed by Waste Dislodging and Conveyance (WD&C) activities. The work objectives are to define system requirements and establish data objectives for all aspects of sludge and saltcake end effector and conveyance tasks, and to coordinate documentation of FY 1994 testing results and comparisons.

FY 1994 Budget: \$200K

Major Milestones:

- Complete integrated work plan - November 1993.
- Formulate integrated testing strategy for EM-30 concurrence - December 1993.
- Complete revised multi-year testing strategy - September 1994.
- Document FY 1994 test results - September 1994.

4.1.4 Integrated Testing

Principal Investigator: B. Hatchel, PNL

Work Statement

This activity will lead the effort for integrated testing of the WD&C system in a single-shell tank environment using a range of waste dislodging and conveyance tools and a variety of simulants. Other activities include designing and preparing an integrated test bed; providing requirements and coordinating equipment from industry, university, and WHC partners; and updating functions and requirements for waste dislodging tools as testing progresses.

FY 1994 Budget: \$500K

Major Milestones:

- Define testbed requirements - December 30, 1993.
- Complete testbed conceptual design document - March 30, 1994.
- Document FY 1994 test results - September 30, 1994.

4.1.5 Waste Dislodging and Conveyance System

Principal Investigator: J. Yount, WHC

Work Statement

This activity will provide technical coordination with Hanford EM-30 tank retrieval tasks to ensure specific technology development and obtain buy-in by the future technology user. Staff will lead the design and acquisition effort for the WD&C testbed. Working with the Integrated Testing activity (RL332011), other activities include assembling the testbed requirements, defining the equipment, performing conceptual and definitive design, supervising installation of equipment, and training operating staff.

FY 1994 Budget: \$400K

Major Milestones:

- Complete integrated WD&C FY 1994 work plan (draft) for EM-30 concurrence - December 30, 1993.
- Revise multiyear testing strategy document/test plans - May 30, 1994.
- Document FY 1994 test results and provide summary report - September 31, 1994.

4.1.6 Medium Pressure Mining Strategy

Principal Investigator: D. Summers, UM/Rolla

Work Statement

Through a contract with the University of Missouri - Rolla, this activity will accomplish the following:

- Complete a technical evaluation of the concept of medium pressure (10,000 psi) dislodging of sludge and salt cake
- Examine the scavenging ability of a jet pump system for conveying waste to the surface for treatment
- Develop mining strategies for a full range of waterjet-based technologies. National lab and industrial partners will be consulted to coordinate test strategies and results.

FY 1994 Budget: \$200K

Major Milestones:

• Complete preliminary ITB design/specifications - December 1993.• Document FY 1994 test results - September 1994.

4.1.7 High Pressure Waterjet Scarification

Principal Investigator: W. Coleman, Quest Integrated, Inc.

Work Statement

Through an industrial partnership with Quest Integrated, Inc., this activity will provide rapid development and acquisition of near-prototype high-pressure dislodging and conveyance system elements. Coupled with pneumatic conveyance technology, this system is intended to retrieve sludge and saltcake without adding appreciable amounts of water to the tanks. University and national lab partners will be consulted to coordinate test strategies and results.

FY 1994 Budget: \$300K

Major Milestones:

- Provide input to preliminary ITB design/specifications - December 1994.
- Provide input to multi-year testing strategy - March 1994.
- Document FY 1994 test results - September 1994.

4.2 Robotics Integrated Program (RIP)

4.2.1 Robotics Cross Cutting and Advanced Technology - PNL

Principal Investigator: M. S. Evans, PNL

Work Statement

This activity comprises four subtasks:

- Development and demonstration of technology for controlling oscillations in manipulator systems that are affected significantly by flexure of structural members, mechanical drives, and actuators. During FY 1994, PNL will implement algorithms developed at PNL, universities, and ORNL on the flexible manipulator located in the 337 High-bay Building at Hanford
- Extension of existing software in flexure and kinematic modeling for inclusion in generalized simulation libraries. PNL will focus on extending its experience with the use of commercially available dynamic, kinematic, structural, and CAD modeling systems to determine the work statement and best method for including these capabilities into generalized simulation libraries available over an interlab network
- Participation in multi-lab review groups investigating 3-D imaging, CCAT Technology Transfer, and university programs
- Development of an advanced ground penetrating radar (GPR) for subsurface mapping of buried waste.

The research and development effort will be performed in conjunction with SNL, who leads the CCAT effort, and with ORNL, who is performing complementary research in the control of flexure in manipulator systems. Results of R&D will be transferred to follow-on activities in support of other programs.

FY 1994 Budget: \$400K

Major Milestones:

• Demonstrate flexure damping algorithms - September 30, 1994.• Complete report on joint force sensor performance - September 30, 1994.• Complete report on extension of existing RTDP modeling capabilities - September 30, 1994.

4.2.2 Robotics Cross Cutting and Advanced Technology - LANL

Principal Investigator: R. M. Hollen, LANL

Work Statement

This activity involves the following work:

- **Sensing Systems** - Develop sensors for controlling robot manipulators and vehicles as well as integrated sensory arrays for in situ characterization of hazardous waste sites. Automated generation of contaminant maps to guide remediation efforts is a product of this activity.
- **Controls** - Develop algorithms for controlling of robotics systems (arms and vehicles) as well as software modules for the Generic Intelligent System Controller approach for general use with RTDP projects.
- **Systems Analysis** - Develop a generalized approach to cost/benefit analyses for application to all RTDP projects. Integrate individual analyses into a general RTDP cost/benefit analysis evaluating RTDP projects as a whole.
- **University R&D Programs** - Sponsor university R&D programs to initiate longer-term focused R&D in advanced technology areas such as software safety and system reliability, robot manipulator control, advanced operator interfaces, advanced sensor interpretation, and environmental technologies.
- **Cooperating Multi-Arm Manipulation** - Develop hardware and control algorithms for the multiple robot arm systems needed to interact cooperatively for manipulating large unwieldy objects.
- **Modeling and Simulation** - Develop a generalized modeling environment for use within RTDP for analyzing and evaluating robot technology concepts. Establish remote network access of modeling capabilities. Initiate development of simulation models for library availability.
- **Technology Transfer** - Develop generalized aggressive technology development plan for RTDP that will stimulate improved interactions between RTDP and industry and move technology from RTDP labs to industry faster. RTDP should be the model for OTD.
- **Project Coordination** - Provides for coordinating and managing the Cross Cutting and Advanced Technology element of RTDP, and hosting the annual DOE Industry/University/Lab Forum.

FY 1994 Budget: \$160K

Major Milestones:

• Select initial sensor combinations - March 31, 1994.• Begin operating automated sensor data analysis algorithm - June 30, 1994.• Complete engineering report on initial algorithm development - September 30, 1994.

4.2.3 Robotics Cross Cutting and Advanced Technology - SNL

Principal Investigator: R. W. Harrigan, SNL

Work Statement

This activity involves work to establish a TWR robotics development test bed system. The purpose of this system is to implement a full-scale development facility for evaluating new manipulator-based retrieval technologies. The test bed will include all major subsystems required for evaluating tank retrieval robotics concepts and will incorporate a realistic mock-up of tank internal features and waste characteristics. Other activities include the following:

- TWR robotics technology development
- EM-30 waste tank retrieval systems support
- SLM chemical validation
- Development of priority SLMs
- SAM system integration
- Support systems integrator SAM commercialization
- AC swing-free crane control
- Automatic workcell model updating
- Surveillance and maintenance risk and cost reduction evaluation mapping, characterization, and inspection system
- Selective equipment removal system (SERS)
- Small pipe characterization system
- Internal duct characterization system
- Sensing systems
- Algorithms for control of robotics systems (arms and vehicles)
- University R&D programs

FY 1994 Budget: \$3980K

Major Milestones:

- Complete project plan for phase I whole arm collision avoidance system - December 31, 1993.
- Demonstrate phase I motion planning algorithms for working with irregular shapes - March 31, 1994.
- Demonstrate phase I collision avoidance - June 30, 1994.
- Demonstrate advanced algorithms for controlling multiple dissimilar robot arms - June 30, 1994.
- Organize and participate in 3-D imaging review group - September 30, 1994.
- Publish final technology transfer plan - September 30, 1994.
- Complete project plan cost-benefit analysis - December 31, 1994.

4.2.4 Decontamination and Dismantlement Robotics - PNL

Principal Investigator: R. S. Stoughton, PNL

Work Statement

The initial focus of this activity is to evaluate the applicability of Variable Geometry Truss (VGT) mechanisms for providing the long reach and dextrous manipulation requirements for decontamination and dismantling (D&D) as part of the Selective Equipment Removal System (SERS). A VGT-based manipulator has the potential to meet these requirements at a fraction of the weight required for a conventional robot structure. Also, the open structure of the VGT can greatly simplify the task of routing cables to the end effector, resulting in a more reliable and rugged total system.

PNL can contribute much expertise to the D&D effort in the analysis, design, and optimization of parallel actuated multi-Degree of Freedom (DOF) mechanisms, and in the design and control of hydraulic actuated robots. NASA Langley Research Center (LaRC) has expertise in the design of lightweight deployable space structures, and has pioneered the development of the VGT. Under this TTP, and under a Memorandum of Understanding between DOE and NASA, PNL will work in cooperation with NASA (LaRC) to develop a VGT manipulator which can be mounted on the mobile D&D platform currently under development at ORNL.

FY 1994 Budget: \$250K

Major Milestones:

- Report on the kinematics of the VGT mechanism - February 1, 1994.
- Establish manipulator specifications - March 1, 1994.
- Complete VGT design of SERS - June 1, 1994.

4.2.5 Robotics Technology Development - Roll Up

Principal Investigator: W. R. Hamel, ORNL

Work Statement

This activity supports the tank waste retrieval (TWR) robotics test bed development. The work involves testing/modifying existing SLMs to prepare for validation; testing actual lab operation of SLMs for EPA Methods 3015, 3520, and 3051; modifying hardware/software; retesting, and documenting results. Other work elements include the following:

- SLM chemical validation
- SAM system integration
- AC swing-free crane control
- Automatic workcell model updating
- Item characterization and sorting
- Development of cryogenic cutting for boxes and bins
- D&D surveillance and maintenance risk
- Cost reduction evaluation methodologies
- Mapping, characterization, & inspection system
- Selective equipment removal system (SERS)
- Small pipe characterization system
- Internal duct characterization system
- Sensing systems

FY 1994 Budget: \$480K

Major Milestones:

- Demonstrate first generation dual arm manipulator - December 31, 1993.
- Validate microwave digestion and digestion filtration SLM - March 31, 1994.
- Finish design and construction of radionuclide plating SLM - June 30, 1994.
- Demonstrate sensor based cooperative dual arm manipulator - June 30, 1994.
- Complete validation of DIM for EPA 8200 for GC/MS - September 30, 1994.
- Transfer swing-free AC crane to industry - September 30, 1994.
- Complete whole arm collision avoidance system report - September 30, 1994.
- Report on flexure damping algorithms - September 30, 1994.

4.2.6 Robotics Tank Waste Retrieval - PNL

Principal Investigator: M. S. Evans, PNL

Work Statement

A significant part of the effort in FY 1994 and beyond is to implement a full-scale, realistic, and comprehensive development facility for evaluating new manipulator-based retrieval technologies. Beneficial use will be implemented in FY 1994, with full capability achieved in FY 1996, and continued use in out years. The test bed will include all major subsystems required for tank retrieval robotics concept evaluations and will incorporate a realistic mock-up of tank internal features and waste characteristics.

PNL, SNL, and ORNL will provide engineering support to manipulator-based retrieval aspects of Hanford storage tank remediation projects. The EM 30 Tank Waste Retrieval System organization at Hanford has requested support from the Tank Waste Retrieval Robotics team in developing functions and requirements, engineering studies, and conceptual designs for the first generation manipulator-based retrieval system. This system will provide heel removal capability following past practice sluicing. The Tank Waste Retrieval Robotics team will also provide support in generating functions and requirements for the second generation retrieval system planned for retrieval of waste from multiple Hanford tanks with a wide variation in waste form and internal hardware configurations.

FY 1994 Budget: \$800K

Major Milestones:

- Complete mapping/viewing demo - March 31, 1994.
- Complete mock-up design - June 30, 1994.
- Demonstrate active sampling - September 30, 1994.
- Test bed facilities operational - September 30, 1994.

4.2.7 Robotics Tanks Waste Retrieval - SNL

Principal Investigator: D. Horschel, SNL

Work Statement

The TWR robotics development test bed activity will implement a full-scale, realistic, and comprehensive development facility for evaluating new manipulator-based retrieval technologies. The test bed will include all major subsystems required for tank retrieval robotics concept evaluations and will incorporate a realistic mock-up of tank internal features and waste characteristics. The TWR robotics technology development activity will develop and evaluate advanced robotics technology options for manipulator-based tank retrieval systems applied across the DOE complex. Several of the newly defined activities require modest resource commitment to prepare for aggressive development activities in out years. The EM-30 TWRS support activity will provide engineering support to manipulator-based retrieval aspects of Hanford storage tank remediation projects.

FY 1994 Budget: \$1250K

Major Milestones:

- Place bed contract.
- Deliver control and data acquisition equipment.
- Demonstrate retrieval system initial simulation.

4.2.8 Robotics Tanks Waste Retrieval - METC

Principal Investigator: B. Beddick, METC

Work Statement

This activity will provide procurement support for the purchase of the long reach manipulator. The Robotics Technology Development Program will provide performance requirements, selection criteria, proposal evaluation, and will select on technical merit the company to be funded by procurement. Morgantown Energy Technology Center (METC) will work with the Lab Team to place the contract in FY 1994.

FY 1994 Budget: \$1600K

Major Milestones:

- Complete LRM Procurement/Generation 2 - June 30, 1994.

4.2.9 Robotics Decontamination and Dismantlement

Principal Investigator: R. W. Harrigan, SNL

Work Statement

This activity involves the following tasks:

- **Surveillance and Maintenance (S&M) Risk and Cost Reduction Evaluation Methodologies** - Develop analysis methodologies for the evaluation of risk and cost/benefit tradeoffs associated with robotics systems in reducing facility S&M costs. Applications for robotics systems during both facility deactivation and continuing S&M will be considered.
- **Mapping, Characterization, and Inspection System** - Develop and demonstrate a multi-purpose mobile robotics-system for facility mapping, contaminant characterization, and inspection functions associated with S&M. Incorporate mapping sensors, hierarchical data acquisition, data management, and data display capabilities for 3-D facility mapping, contaminant mapping, and recordkeeping, and contamination/configuration tracking. Include cost effective operator control and automation features.
- **Selective Equipment Removal Systems (SERS)** - Demonstrate and evaluate a mobile telerobotic system suitable for performing selective decontamination and dismantling functions applicable to pre-S&M facility preparations. The SERS will use the reconfigurable dual arm manipulation module being developed in CC&AT to demonstrate inspection and equipment removal operations.
- **Small Pipe Characterization System** - Design, procure, fabricate, integrate and demonstrate an integrated system for characterizing contaminants in pipes with internal diameters between one and three inches.

FY 1994 Budget: \$650K

Major Milestones:

- Assess available methodologies - December 31, 1993.
- Complete Conceptual design of facility mapping system - December 31, 1993.
- Demonstrate interactive task-space scene - June 30, 1994.
- Demonstrate mapping system - September 30, 1994.
- Demonstrate and evaluate telerobotic operation - September 30, 1994.

4.3 Buried Waste Integrated Demonstration (BW-ID)

4.3.1 Cooperative Telerobotic Retrieval

Principal Investigator: B. Griebenow, INEL

Work Statement

The objective of this activity is the system design for selective retrieval to be achieved by multiple manipulator capability, and expansion of the existing control system to achieve the necessary axes of control. Three subtasks should be explored to meet this objective: 1) A remotely operated vacuum system to remove soil from a dig face for use in conjunction with a six-degrees-of-freedom manipulator, such as the manipulator currently available on the BW-ID multi-axis crane. Mobility of the vacuum system shall be determined through engineering studies and generation of functional design criteria. Potential modes of mobility include the use of an unmanned ground vehicle, such as proposed in TTP ID142006, a skid system attached to the crane hook, or a system mounted on the crane trolley. The designed vacuum system should include a system for containment of the exhumed soil. The system will also include a multiple end effector to allow exhumation of various types of soil. 2) The existing BW-ID Multi-Axis Crane to increase versatility. These modifications should include the addition of multiple manipulator capability to support complex handling, rigging, and transport operations. A currently available five-degrees-of-freedom manipulator could be integrated into the system to support the current six-degrees-of-freedom manipulator. The system controller may be expanded to accommodate the additional degrees of freedom. An appropriate software interface will be incorporated. 3) Testing and demonstration of the cooperative telerobotic retrieval systems.

FY 1994 Budget: \$900K

Major Milestones:

- Complete draft test plan - February 28, 1994.
- Modify and enhance the multi-axis crane - May 30, 1994.
- Conduct performance tests - June 30, 1994.
- Draft technology evaluation report - September 30, 1994.

4.3.2 Cryogenic Cutting System Demonstration

Principal Investigator: D. N. Bingham, INEL

Work Statement

This task will enhance and demonstrate cryogenic jet cutting technology for BW-ID application (pretreatment of retrieved waste). The low pressure subsystems hardware will be acquired and installed and the configuration tested and documented. Hardware for the high-pressure subsystem will be acquired and installed. Configuration and test results will be documented. Existing nozzle designs will be tested for effectiveness and modified to improve performance. Modified nozzle designs will be evaluated at both high and low pressures on a variety of materials. Test results will be documented.

FY 1994 Budget: \$395K

Major Milestones:

- Complete draft test plan - February 1, 1994.
- Complete demo/testing - June 1, 1994.
- Deliver draft technology report - August 1, 1994.

4.3.3 System Health Monitoring

Principal Investigator: R. MacDonald, INEL

Work Statement

This activity will develop and demonstrate a system health monitoring and failure prediction system. The system should be capable of monitoring hydraulic, mechanical, and electrical systems that will be used by the Buried Waste Integrated Demonstration (BW-ID) program for future field demonstrations. The objective of system health monitoring is to provide an operator with information to assess the health of a system, limit the operator actions that can assess the health of a system, limit the operator actions that can damage the machine, and provide emergency override mechanisms.

Algorithms contained in software modules will be provided for real time analysis of trend data to determine failure prediction data on equipment specified by the BW-ID. Software module development will be performed on bench-scale test systems. Testing will be done on the system to verify and evaluate the algorithms. In FY 1995, the system health monitoring system needs to be demonstrated on equipment deployed in the field by BW-ID to perform the capabilities discussed above and then to demonstrate, test, and evaluate the system.

FY 1994 Budget: \$500K

Major Milestones:

- Complete draft technology test plan - January 15, 1994.
- Complete collection of failure data - June 1994.
- Complete draft FY 1994 evaluation report - September 15, 1994.

4.4 Technology Development Partnerships

4.4.1 Interactive Computer-Enhanced Remote Viewing System

Principal Investigator: J. Wagner, Mechanical Technologies

Work Statement

The integrated computer enhanced remote viewing system can provide a reliable geometric description of a remote environment. The system will serve as a critical subsystem that will allow robotics remediation tasks to be conducted more effectively and economically than with present systems.

FY 1994 Budget: \$344K

Major Milestones:

- Develop major ICERVS subsystems - August 30, 1993.
- DOE decision to start Phase II - September 30, 1993.
- Complete integration and testing subsystems - September 30, 1994.
- DOE decision to start Phase III - September 30, 1994.

4.5 Activity Table

Table 4.1 lists the planned activities and budgets for the retrieval activities.

Table 4.1. Activities Related to TWRS - Retrieval

	Performing Organization	Budget
Underground Storage Tank Integrated Demonstration (UST-ID)		
Simulant Development	PNL	100
Waste Dislodging and Conveyance Mechanics	PNL	800
Test Requirements & Evaluation	PNL	200
Integrated Testing	PNL	500
Waste Dislodging and Conveyance System	WHC	400
Medium Pressure Mining Strategy	UM/Rolla	200
High Pressure Waterjet Scarification	QI	300
		<u>2500</u>
ROBOTICS Integrated Program		
Robotics Cross Cutting and Advanced Technology	PNL	400
Robotics Cross Cutting and Advanced Technology	LANL	160
Robotics Cross Cutting and Advanced Technology	SNL	3980
Decontamination and Dismantling Robotics	PNL	250
Robotics Technology Development - Roll Up	ORNL	480
Robotics Tank Waste Retrieval	PNL	800
Robotics Tank Waste Retrieval	SNL	1250
Robotics Tank Waste Retrieval	METC	1600
Robotics Decontamination and Dismantlement	SNL	650
		<u>9570</u>
Buried Waste Integrated Demonstration (BWID)		
Cooperative Telerobotic Retrieval	INEL	900
Cryogenic Cutting System Demonstration	INEL	395
System Health Monitoring	INEL	500
		<u>1795</u>
Technology Development Partnerships		
Interactive Computer-Enhanced Remote Viewing System	Mech. Tech	344
EM-50 Retrieval Total		<u>14209</u>

Table 4.1. (contd)

	Performing Organization	Budget
Subtotals	PNL	3050
	WHC	400
	ORNL	480
	SNL	5880
	INEL	1795
	LANL	160
	Others	2444
Balanced Total		<u>14209</u>

5.0 Barriers

5.1 Volatile Organic Compound (VOC) Arid Integrated Demonstration (VOC-Arid ID)

5.1.1 Design and Evaluation

Principal Investigator: K. Roberson, PNL

Work Statement

This activity integrates the simulator user interface module developed in FY 1993 with the standard LANL simulators that have been used on the Non-Arid ID and other programs. The product will be a physical work station for commercialization and transfer that provides capabilities for design and evaluation of all the primary VOC-Arid ID technologies, as well as generic capabilities for use in the field design of a suite for other technologies.

FY 1994 Budget: \$835K

Major Milestones:

- Complete test plan - November 30, 1993.
- Demonstrate remediation simulation with heterogeneous arid data set - May 31, 1994.
- Demonstrate complete engineering simulator software - October 31, 1994.

5.1.2 Drilling Technology

Principal Investigator: G. McLellan, WHC

Work Statement

This activity includes purchase of sonic drilling equipment and testing for drilling deep vertical and angle wells. It includes final demonstrations of the cone penetrometer and integration with sensors. A new air turbine drilling tool for horizontal drilling will be tested to demonstrate capability with Hanford soil conditions.

FY 1994 Budget: \$1490K

Major Milestones:

- Issue final cone penetrometer report - June 30, 1994.
- Complete horizontal drilling systems drawings - October 30, 1994.
- Demonstrate automated sonic rig - October 31, 1994.

5.1.3 Sonic Drilling

Principal Investigator: J. Wise, WSRC

Work Statement

This activity addresses the evaluation and improvement of the performance of resonant sonic drills for low angle, slant hole drilling (approximately 20 degrees from horizontal).

FY 1994 Budget: \$340K

Major Milestones:

- Complete conceptual test plan - November 30, 1993.
- Begin Testing Improved system - June 30, 1993.

5.2 Mixed Waste Landfill Integrated Demonstration (MWL-ID)

5.2.1 Measurement While Drilling

Principal Investigator: R. Floran, SNL

Work Statement

The Principal Investigator needs to submit information to task summary and proposed outyear funding.

FY 1994 Budget: \$275K

Major Milestones:

- Report field test of MWD prototype - June 30, 1994.
- Report field test of full MWD prototype - July 30, 1994.

5.2.2 Subsurface Barrier Emplacement Development

Principal Investigator: R. Finely, SNL

Work Statement

This work will evaluate, test, and demonstrate the placement of horizontal barriers beneath waste sites from directionally drilled boreholes. Advanced barrier materials will be used. The FY 1994 work includes the use of jet grouting in directional boreholes and integrity evaluations of the emplacement.

FY 1994 Budget: \$500K

Major Milestones:

- Complete Test plan for permeation and/or jet grouting subsurface barrier - June 30, 1994.
- Report use of ISR-IP international grout formulations - July 31, 1994.
- Report integrity evaluations - September 30, 1994.

5.2.3 Dry Barrier Applications for Landfills

Principal Investigator: J. C. Stormont, SNL

Work Statement

This task will develop and demonstrate an air-enhanced dry barrier for application to landfills in arid environments. FY 1994 activities will include the analysis and evaluation of data gathered in FY 1993, including a comparison to other barrier technologies.

FY 1994 Budget: \$475K

Major Milestones:

- Report field demonstration - August 31, 1994.
- Complete data analysis and evaluation - September 30, 1994.

5.2.4 Cross Borehole Electromagnetic Imaging

Principal Investigator: D. J. Borns, SNL

Work Statement

This activity will demonstrate cross borehole electromagnetic imaging to characterize heavy metal contaminant sources and their migration beneath several locations at SNL. FY 1994 activities include the analysis of data collected previously and the generation of a 2-D tomographic image of the Chemical Waste Landfill. Both the pulsed radar and continuous waveform methods were used to generate data.

FY 1994 Budget: \$120K

Major Milestones:

- Analyze FY 1993 data - April 15, 1994.

5.2.5 Hybrid Directional Boring and Horizontal Logging

Principal Investigator: R. P. Wemple, SNL

Work Statement

This activity will develop cost effective, high-quality access for site characterization and sensor emplacement. FY 1994 tasks will include completing the development of the machinery and demonstrating machinery. In addition, a commercialization plan will be developed to indicate the marketing effort for this machine.

FY 1994 Budget: \$200K

Major Milestones:

- Complete test plan - January 1, 1994.
- Complete summary report on progress - January 15, 1994.
- Complete commercialization plan - March 30, 1994.

5.2.6 In Situ Containment and Stabilization of Buried Waste

Principal Investigator: L. Kukacka, BNL

Work Statement

This activity will to develop, demonstrate and implement advanced grouting materials for the in situ stabilization of contaminated soils. In addition, these grouts will be used for the in-situ installation of impermeable, corrosion resistant caps and subsurface barriers around waste sites. Success will be measured by hydraulic and geochemical isolation of liquid and solid contaminants within the CWL and MWL.

FY 1994 Budget: \$200K

Major Milestones:

- Complete stabilized mixed waste leaching evaluations - June 30, 1994.
- Evaluate subsurface barrier core samples - September 30, 1994.

5.3 In Situ Remediation Integrated Program (ISR-IP)

5.3.1 Chemically Enhanced Barriers to Minimize Contaminant Migration of Sediments

Principal Investigator: K. J. Cantrell, PNL

Work Statement

This activity will develop and determine the effectiveness of a) hydraulic and diffusion barriers and b) permeable barriers to be used in vadose or aquifer sediments to minimize contaminant migration. This will be accomplished by mixing chemical reagents directly within the barrier materials or placing a layer of reagents next to the barriers. The chemical reagents tested will include quaternary alkyl ammonium salts bound by cation exchange to clay, capable of adsorbing uncharged organics such as chlorinated hydrocarbons; hydrotalcite-like minerals for binding anions such as iodide, cyanide, and pertechnetate; and reducing agents such as sodium sulfide and ferrous salts to convert mobile oxyanions and oxycations to immobile reduced forms.

FY 1994 Budget: \$500K

Major Milestones:

- Complete field demonstration plan - August 31, 1994.
- Complete field demonstration - September 30, 1994.

5.3.2 Cryocell Technology Applications at Oak Ridge

Principal Investigator: R. Swatzell, ORNL

Work Statement

As part of this activity, the procurement process will be used to obtain the services of a private company to demonstrate a containment technology that provides a subsurface frozen barrier for isolating radioactive and hazardous wastes in soil.

FY 1994 Budget: \$500K

Major Milestones:

- Complete field test - January 30, 1994.

5.3.3 Evaluation of Two New Flowable Grout Techniques for In Situ Barrier Construction

Principal Investigator: J. Rea, SNL

Work Statement

Two new grout barrier materials will be evaluated under a range of soil conditions found at DOE sites. The grouts are composed of a bentonite clay/natural paraffin mixture developed by German companies and an inorganic grout developed by a French company. Tests will be conducted to resolve questions concerning the compatibility of the barrier materials with anticipated waste forms, the ability to construct a barrier that is laterally extensive, and the physical and hydraulic integrity of the barrier.

FY 1994 Budget: \$350K

Major Milestones:

- Complete test plan for single borehole - July 31, 1993.
- Complete single borehole injection - September 30, 1993.
- Issue technical report - December 31, 1993.
- Complete test plan for multiple boreholes - December 31, 1993.

5.3.4 Containment of Contaminants Through Physical Barriers From Viscous Liquids Emplaced Under Controlled Viscosity Conditions

Principal Investigator: K. Pruess, LBL

Work Statement

This task will identify and evaluate liquids with temperature-dependent viscosity or sets of two fluids which, when mixed and heated to a desired temperature, produce nearly inert impermeable materials that solidify at average aquifer temperatures. The ability of these substances to provide an effective containment of the contaminated zone by entrapping and immobilizing both the contaminant source (if any) and the plume will be investigated. The containment ability of this approach will be evaluated by means of numerical simulation, large-scale laboratory experimentation, and field testing/demonstration.

FY 1994 Budget: \$650K

Major Milestones:

- Complete numerical model for process simulation - February 28, 1994.
- Complete demonstration plan - March 30, 1994.
- Complete design package for emplacement - September 30, 1994.

5.3.5 Hydraulic and Diffusion Barriers in the Vadose Zone Surrounding Buried Waste

Principal Investigator: J. Heiser, BNL

Work Statement

This task will investigate and identify the regulatory issues, drivers, and key assumptions associated with aspects of barrier installation. Specific barrier materials will be developed and tested for durability, permeability to water, ionic diffusivity, wet/dry cycling, freeze/thaw cycling, and chemical resistivity to acid, base and solvent conditions under typical waste site conditions. All formulations will be capable of being placed as vertical barriers through conventional construction methods to depths of at least 20 feet.

FY 1994 Budget: \$235K

Major Milestones:

- Complete lab-scale experiments - March 30, 1994.
- Complete bench-scale demonstration test plan - June 30, 1994.

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5.3.6 Research and Demonstration for Cryogenics Containment Barriers in Arid Sites

Principal Investigator: S. Schweissing, BNL

Work Statement

This project will conduct the research and demonstration activities to determine the applicability and performance of cryogenic barriers at arid sites.

FY 1994 Budget: \$487K

Major Milestones:

- Finalize R&D Subcontractor - November 30, 1993.
- Complete and issue report - July 31, 1994.

5.3.7 Independent Verification of Land Containment System

Principal Investigator: D. Ridenour, BNL

Work Statement

Evaluate, for integrity, a horizontal grout barrier slab formed in situ using high-pressure jet grouting techniques.

FY 1994 Budget: \$250K

Major Milestones:

- Complete test plan - October 30, 1993.
- Complete field test - January 30, 1994.

5.3.8 Develop/Demonstrate Methods of Placing Horizontal In Situ Grout Barriers

Principal Investigator: D. Ridenour, BNL

Work Statement

This task will develop a new technology system for constructing in situ subsurface barriers by combining technologies developed by OTD with new materials emplacement technology devised by industry.

FY 1994 Budget: \$300K

Major Milestones:

- Complete demonstration plan - October 31, 1993.

5.4 Technology Development Partnerships

5.4.1 Soil Saw Demonstration

Principal Investigator: K. Saugier, Halliburton, NUS

Work Statement

The soil saw is an innovative method for forming underground cut-off walls for environmental remediation or civil construction. This method is an *in-situ*, one-step method which eliminates the excavation and replacement process and greatly improves the quality of the final product.

FY 1994 Budget: \$1121K

Major Milestones:

- Complete slurry wall construction - February 28, 1994.
- Complete test wall sampling - April 30, 1994.
- Develop predictive model - May 30, 1994.
- Complete final report - July 30, 1994.

5.5 Activity Table

Table 5.1 lists the planned activities and budgets for the barrier activities.

Table 5.1. Activities Related to TWRS - Barriers

	Performing Organization	Budget
Volatile Organic Compound (VOC) Arid Integrated Demonstration(VOC-ID)		
Design and Evaluation	PNL	835
Drilling Technology	WHC	1490
Sonic Drilling	WSRC	340
		<u>2665</u>
Mixed Waste Landfill Integrated Demonstration (MWL-ID)		
Measurement While Drilling	SNL	275
Subsurface Barrier Emplacement Development	SNL	500
Dry Barrier Applications for Landfills	SNL	475
Cross Borehole Electromagnetic Imaging	SNL	120
Hybrid Directional Boring and Horizontal Logging	SNL	200
In-Situ Containment and Stabilization of Buried Waste	BNL	200
		<u>1770</u>
In-Situ Remediation Integrated Program (ISR-IP)		
Chemically Enhanced Barriers to Minimize Contaminant Migration of Sediments	PNL	500
Cryocell Technology Applications at Oak Ridge	ORNL	500
Evaluation of Two New Flowable Grout Techniques for In-Situ Barrier Construction	SNL	350
Containment of Contaminants Through Physical Barriers from Viscous Liquids Emplaced Under Controlled Viscosity Conditions	LBL	650
Hydraulic and Diffusion Barriers in the Vadose Zone Surrounding Buried Waste	BNL	235
Research and Demonstration for Cryogenics Containment Barriers in Arid Sites	BNL	487
Independent Verification of Land Containment System	BNL	250
Develop/Demonstrate Methods of Placing Horizontal In-Situ Grout Barriers	BNL	300
		<u>3272</u>

Table 5.1. (contd)

	Performing Organization	Budget
Technology Development Partnerships		
Soil Saw Demonstration	NUS	<u>1121</u>
EM-50 / Barrier Total		<u>8828</u>
 Subtotals		
	PNL	1335
	WHC	1490
	ORNL	500
	SNL	1920
	BNL	1472
	WSRC	340
	Others	<u>1771</u>
 Balanced Total		<u>8828</u>

6.0 Pretreatment

6.1 Underground Storage Tank Integrated Demonstration (UST-ID)

6.1.1 Compact Process Unit

Principal Investigator: W. Richmond, PNL

Work Statement

Develop process and equipment for first-stage processing of waste from underground tanks.

Working closely with Hanford EM-30, this activity will develop the process and equipment for a Compact Processing Unit (CPU). The CPU provides the flexibility to accommodate the significant variations between storage tanks. Design requirements to be developed will include phased process deployment, field deployment, field maintenance, and satisfaction of all safety and permitting criteria. The CPU will be designed to accommodate processes other than Cs extraction and include requirements for CPU deployment beyond Hanford. Working as a team composed of WHC, Ebasco/British Nuclear Fuels Limited (BNFL) and PNL, a work plan, project structure, and philosophy will be developed early in the fiscal year.

FY 1994 Budget: \$1500K

Major Milestones:

- To be identified

6.1.2 Cesium Extraction

Principal Investigator: J. P. Bibler, WSRC

Work Statement

This work will focus on the continued development of a resorcinol/formaldehyde resin, coordinating the development and testing of the resin with other EM projects. Planned activities include the following:

- Provide technical support to British Nuclear Fuels Limited (BNFL) for initial resin testing in the skid-mounted ion exchange demonstration unit to be preformed at SRS.
- Provide input to the Compact Process Unit (CPU) project to ensure accuracy of ion exchange specifications and compliance with regulations.
- Provide technical liaison for work conducted at Clark University in evaluating the effects of aging on the resin.
- Complete and issue two reports, the first providing the results of the aging studies and the second providing a complete assessment of the resin's performance and use in the CPU.

FY 1994 Budget: \$200K

Major Milestones:

• Update ProTech profile - February 28, 1994.• Complete resorcinol resin degradation assessment - June 30, 1994.

6.1.3 Comprehensive Demonstration of Sludge and Supernate Processing

Principal Investigator: Z. Egan, ORNL

Work Statement

This activity will continue to develop a comprehensive sludge and supernate processing flowsheet through actual demonstration of pretreatment/separations technologies using ORNL Melton Valley Storage Tank waste as the feed. Information from this program will be provided to LANL and Hanford site staff to assist in their system engineering assessment of the performance and compatibility of the technologies.

FY 1994 Budget: \$1400K

Major Milestones:

- Conduct initial batch evaluation of resorcinol-formaldehyde resin and sodium silicotitanate for Cs removal - January 31, 1994.
- Complete Bench-scale studies on extraction of nitric acid and bismuth with CMPO indodecane - March 31, 1994.
- Report initial evaluation of sorbents for removing cesium and strontium - March 31, 1994.
- Characterize acid dissolution of sludge - April 30, 1994.

6.1.4 Technical Interchange with Commissariat á l'Energie Atomique (CEA)

Principal Investigator: B. Jubin, ORNL

Work Statement

This activity will initiate the French technical interchange, providing guidance on a continuing basis. Upon completion of this subtask in FY 1995, a final report will be prepared to address CEA development of technologies applicable to the USTID mission.

FY 1994 Budget: \$350K

Major Milestones:

- Complete final report on technical interchange with CEA - May 30, 1995.

6.1.5 TRUEX Validation and Data Collection

Principal Investigator: K. Felker, ORNL

Work Statement

This work will focus on completing data analysis for demonstration tests using a Mark-42 target. Tasks include 1) compare the data to the Generic TRUEX Model (GTM), and 2) issue a report.

FY 1994 Budget: \$125K

Major Milestones:

- Issue report on TRUEX demonstration and GTM evaluation - March 31, 1994.

6.1.6 Clean Option Support

Principal Investigator: D. Malkemus, ORNL

Work Statement

This activity will assist the TWRS team working on flowsheet development. Tasks include the following: 1) study the operability of the CPU concept and 2) interface with the Clean Option committees of TWRS and with the Waste Processing and Disposal Steering Committee.

FY 1994 Budget: \$300K

Major Milestones:

- Provide operability studies for the clean option - September 30, 1994.

6.1.7 Organics Destruction Process Development

Principal Investigator: Hunt, ORNL

Work Statement

The purpose of this work is to determine which technologies being developed by industry and universities can destroy organics found in UST wastes, and recommend projects to the DOE for subsequent funding. This analysis is to be done by using standard procurement practices (i.e., Request for Expression of Interest in Commerce Business Daily). A team involving a procurement specialist from ORNL, program engineers, and a professor from the University of Nebraska experienced in organics destruction will be established to develop criteria and evaluate responses. The team is to make recommendations on future direction to the DOE HQ program manager.

FY 1994 Budget: \$100K

Major Milestones:

- Submit RFI announcement - November 30, 1993.
- Complete review of RFI responses - March 31, 1994.
- Submit recommendations report - June 30, 1994.

6.1.8 TRUEX Model Development

Principal Investigator: G. F. Vandergrift, ANL

Work Statement

This work continues support to researchers at ORNL who are evaluating the TRUEX process on actual HLW and TRU wastes from Mark-42 targets. Researchers will suggest changes in dissolution procedures or the Generix TRUES Model (GTM) to resolve discrepancies. They will also compare results from the PNC study with predicted GTM results and use ORNL experimental data to refine and validate the GTM. A contract will be established with the University of Illinois (\$30K) to collect data on extraction behavior and with Spring Harbor College (\$10K) to develop a model for extracting actinides.

FY 1994 Budget: \$300K

Major Milestones:

- Update the ProTech file - February 28, 1994.
- Provide GTM-calculated flowsheets for TRUEX demonstration by PNC - April 30, 1994.
- Report the GTM validation using ORNL and PNC data - September 30, 1994.

6.1.9 Mobile Evaporator and Concentrator

Principal Investigator: Chamberlain, ANL

Work Statement

This activity will contract with LICON to develop a mobile evaporator/concentrator unit for removing the significant amount of water that will likely be added to waste during retrieval operations. Equipment will be procured and tested to determine the potential for discharging decontaminated condensate to the soil column.

FY 1994 Budget: \$600K

Major Milestones:

- Issue design criteria - January 31, 1994.
- Complete ProTech profile - February 28, 1994.
- Issue test plan - June 15, 1994.
- Conduct initial tests - August 31, 1994.

6.2 Efficient Separations and Processing Integrated Program (ESP-IP)

6.2.1 Alkaline Tank Sludge Treatment

Principal Investigator: R. Quinn, PNL

Work Statement

This activity will 1) determine the characteristics of Hanford tank sludges to support sludge dissolution/leaching studies at both ORNL and Hanford; 2) assess the ability of the ACT*DE*CONSM process to separate radionuclides from sludge-type wastes; and 3) identify and test complexing agents for separating radionuclides from the nonradioactive process chemicals in sludges.

FY 1994 Budget: \$600K

Major Milestones:

- Complete Phase I draft report - February 28, 1994.
- Evaluate funding for Phase II - April 15, 1994.
- Complete annual progress report - June 1, 1994.
- Complete Phase II award - June 1, 1994.
- Complete installation of Phase II equipment - September 30, 1994.

6.2.2 Develop and Test Sorbents

Principal Investigator: D. Wester, PNL

Work Statement

The purpose of this work is to develop high-capacity, selective solid extractants for removing Cs, Sr, Cr, Ag, Tc and noble metals from nuclear wastes. This activity will test sorbents, solid sequestering agents, ion exchange media, etc. developed within ESP-IP. It will also develop high-capacity ion exchangers through Allied Signal Corporation and develop high-capacity fixed sequestering agents through 3M Company.

FY 1994 Budget: \$2150K

Major Milestones:

Task 1 - PNL

- Complete plan for hot cell testing - November 15, 1994.
- Complete annual progress report - June 1, 1994.
- Complete letter report on hot cell tests - June 30, 1994.

Task 2 - Allied Signal

- Complete Phase II testing of industrial candidates; provide letter report on work - December 31, 1993.
- Complete investigation of advanced inorganic sequestering agents - September 15, 1994.
- Complete a Phase III extension proposal - June 15, 1994.

Task 3 - 3M

- Complete Phase II work - February 28, 1994.
- Complete Phase III extension proposal - July 15, 1994.
- Complete cold testing of 1/10 scale unit - September 15, 1994.

6.2.3 Significant Volume Reduction of Tank Waste by Selective Crystallization

Principal Investigator: Herting, WHC

Work Statement

This activity will develop and demonstrate a large-scale crystallization process to reclaim sodium nitrate as a clean, nonradioactive salt for inclusion in the EM-30 baseline tank waste treatment.

FY 1994 Budget: \$300K

Major Milestones:

- Study solubility interaction of waste tank components and crystal growth methods; issue report - August 15, 1994.
- Develop surrogate tank waste to encompass wide range of tank waste compositions; issue report - September 30, 1994.
- Study Cs to Na ratio impact on ion exchange; study decreased concentration of sodium nitrate impact on final waste forms; issue report - September 30, 1994.
- Create flowsheet model; identify all usable unit operations; evaluate, rank, and select unit operations; complete optimized flowsheet model - September 30, 1994.

6.2.4 Fission Product Separation Using Ion Exchange, Solvent Extraction and CODCB

Principal Investigator: Attrep, LANL

Work Statement

The purpose of this task is to investigate new systems for partitioning technetium from Hanford waste streams, investigate ion exchange technologies for removing nickel, and develop new cobalt dicarbollide systems for removing of cesium and strontium.

FY 1994 Budget: \$850K

Major Milestones:

- Investigate new ion exchange and liquid extraction materials for the removal of Tc - September 30, 1994.
- Evaluate ion exchanges for Ni removal - September 30, 1994.
- Synthesize, graft, and evaluate CODCB materials for removal of Cs and Sr - September 30, 1994.

6.2.5 Solid Sequestering Agents; Removal of Transuranics

Principal Investigator: Jarvinen, LANL

Work Statement

This activity is divided into three subtasks: develop polysupported, ion-specific extraction systems for removing actinides and other ions from waste water streams; conduct comparison liquid-liquid extraction tests of alkylmalonamides against CMPO CMP ion terms of extraction, back-extraction, and stability using simulated solutions that include species of challenge to diamide extraction (similar to Hanford waste streams); and synthesize and evaluate the separation factor and ligand stability for advanced extractants using Eu/Am or comparable systems for testing.

FY 1994 Budget: \$900K

Major Milestones:

- Further evaluate new water-soluble chelating polymers for engineering parameters and develop linking technology - August 30, 1994.
- Using appropriate mock waste solutions, simultaneously compare CMPO/CMP/AMA for extraction, stability, emulsions/third-phase formation - August 30, 1994.
- Evaluate and compare the ligand systems selected, using Eu and Am as test metals - August 30, 1994.

6.2.6 Aqueous Biphasic Systems; Radioactive Waste Pretreatment

Principal Investigator: Chaiko, ANL

Work Statement

The objective of this task is to develop aqueous biphasic separation (ABS) systems for pretreating supernatant solutions from underground storage tanks. Subtasks include determining phase diagrams and optimizing an ABS system for extracting Tc, I, and Se; determining partitioning of SNL silicotitanate material in an ABS system; and describing a target application.

FY 1994 Budget: \$350K

Major Milestones:

- Define flowsheet for target application - March 30, 1994.
- Submit annual report - September 30, 1994.
- Complete glovebox tests with tracer labeled waste - September 30, 1995.

6.2.7 Advanced Processing for Clean Option

Principal Investigator: Horwitz, ANL

Work Statement

The purpose of this task is to develop a combined TRUEX/SREX solvent extraction system that supports the "Clean Option" strategy for comprehensive partitioning of radionuclides into a HLW form and reduction of LLW form toxicity to NRC Class A. This includes conducting cold and hot countercurrent tests of the combined TRUEX/SREX system, and conducting column tests of An/Ln separation. A baseline flowsheet for the TOREX process will be provided, describing the process in terms of major chemical components and species involved and their mass balances.

FY 1994 Budget: \$400K

Major Milestones:

- Develop and test the actinide(III)/lanthanide(III) separation process - March 31, 1994.
- Design the planned cold and hot testing of the NREX-NEPEX flowsheet - July 31, 1994.

6.2.8 In Situ Magnetically Assisted Chemical Separation (MACS)

Principal Investigator: Nunez, ANL

Work Statement

This process combines the selective and efficient separation provided by chemical sorption with the magnetic recovery capability of ferromagnetic beads. This project will develop compact, economic, in-tank or near-tank processes for removing contaminants from solution at Hanford and other DOE sites. The process uses magnetic beads coated with 1) either a selective ion exchange material or an organic complexant-containing solvent for Cs and Sr removal, or 2) solvents for selective separation of TRU. The beads are formed using iron or other magnetic material coated with either organic polymer or ion exchange resin.

The greatest benefit of the technology is the simple separation of radionuclides from waste in a cost-efficient and compact process without producing large waste streams, and the application of this process to many DOE liquid TRU wastes.

FY 1994 Budget: \$350K

Major Milestones:

- Remove cesium from Hanford tank supernatant -
- Remove TRU from dissolved sludge -
- Remove strontium from dissolved sludge -
- Remove TRU from Hanford supernatants and sludge-wash suspension -
- Install, test, and demonstrate an in-laboratory MACS unit -

6.2.9 Sludge Washing and Dissolution of ORNL MVST Waste

Principal Investigator: P. McGinnis, ORNL

Work Statement

This activity will focus on work to test, model, and evaluate HLW tank sludge processing. The following activities will be conducted:

- Perform experimental work and modeling to support development of a sludge/supernatant processing flowsheet being prepared under the USTID.
- Evaluate removal of aluminum from Hanford and INEL wastes by dissolution in concentrated caustic.
- Determine conditions under which hydrous oxides will be dispersed as colloids during leaching and washing operations.
- Identify, synthesize, and test crown ethers for extraction of Tc from alkaline solution.
- Serve as Deputy Integrated Program coordinator.
- Identify radiolysis products and effects of radiolysis of the solvent on overall separation performance.
- Select a system of waste, contaminant, and exchange resin and conduct bench-scale tests to collect data for design of a pilot-scale program.

FY 1994 Budget: \$2050K

Major Milestones:

- Report results of scoping tests used to determine solubility of the organic phase in the aqueous stream under various conditions - June 30, 1994.
- Complete test on Hanford and INEL simulated sludges and issue report on solubility of aluminum and other metals in caustic solutions - September 30, 1994.
- Perform scoping tests of colloid formation during leaching and washing - September 30, 1994.
- Test and define crown ether solvent extractions cycle for Tc and issue letter report - September 30, 1994.
- Provide an initial comparison of model prediction versus measured results of sludge tests and issue letter/report - September 30, 1994.
- Complete bench-scale tests and issue letter report - September 30, 1994.
- Report final sludge washing and leaching test results - September 30, 1995.

6.2.10 Crystalline Silicotitanate for Cs/Sr Removal

Principal Investigator: Brown, SNL

Work Statement

Develop crystalline silicotitanate (CST) materials for removal of Cs and Sr, particularly from alkaline HLW tank supernatant. Provide samples for performance testing at PNL, SRS, INEL, and ANL. Fund industrial partner producing engineered CST materials.

FY 1994 Budget: \$675K

Major Milestones:

- Complete evaluation of CST for Cs removal from acidic wastes at INEL - December 23, 1993.
- Determine structure and properties of CST - July 15, 1994.
- File report on CST performance on actual waste tests at PNL, ORNL, INEL, and WSRC - September 30, 1994.

6.2.11 Development and Evaluation of Electrochemical Methods for Destroying Nitrates and Organics

Principal Investigator: Hobbs, WSRC

Work Statement

An electrochemical treatment process will be developed for destroying nitrate, nitrite, and organic compounds and removing radionuclides and hazardous metals from alkaline wastes.

FY 1994 Budget: \$850K

Major Milestones:

- Identify wastes currently stored throughout the DOE complex that are possible candidates for electrochemical treatment - December 31, 1993.
- Conduct electroanalytical testing to determine cathodic and anodic reaction rates - July 30, 1994.
- Identify and determine composition of candidate waste streams that exist throughout the DOE complex that may be amenable to electrolytic treatment - September 30, 1994
- Evaluate porous metal electrodes and gas diffusion anodes to determine if these types of electrodes offer any appreciable advantage for the destruction of nitrate and nitrite compared to planar electrodes and anodes - September 30, 1994.
- Complete design of pilot-plant test facility for demonstrating electrochemical treatment of liquid wastes - December 12, 1994.

6.3 Mixed Waste Integrated Program (MW-IP)

6.3.1 Freeze Crystallization Technology for Concentrating and Partitioning Liquid Waste

Principal Investigator: J. Wong, WHC

Work Statement

This work will develop and demonstrate pilot-scale, direct-contact freeze crystallization systems for showing that freeze crystallization technology is capable of concentrating liquid effluents, and separating organic and inorganic contaminants by removing the bulk of the water. A freeze crystallization process separates water from solutions by cooling the solution until ice crystals begin to form. Ice, with a few exceptions, crystallizes as a pure material. The ice is separated from the remaining liquid and impurities, washed, and melted to produce a purified stream. Hazardous wastes are concentrated into a reduced volume, which can be more economically destroyed by thermal oxidation or solidified.

FY 1994 Budget: \$600K

Major Milestones:

- Report on economics/benefits of technology - February 28, 1994.
- Complete mid-year progress report - March 31, 1994.
- Complete final report - September 30, 1994.
- Present full-scale system decision - September 30, 1994.

6.3.2 Steam Reforming to Destroy Organic Materials and Nitrates

Principal Investigator: J. L. Sprung, SNL

Work Statement

This task will use the commercial steam reforming system of Synthetica Technologies to demonstrate the destruction of organics and inorganic salts that decompose thermally (e.g., nitrates, nitrites, carbonates). The following waste simulants will be tested:

- adsorbed aqueous organic liquids waste
- high organic content sludge
- cemented sludge/ash/solids
- heterogenous debris
- lab packs
- Trimsol coated machining waste.

In addition, scavenging of mercury vapor by molten sulfur coated on ceramic spheres will be studied to determine whether Synthetica's ceramic sphere packed Moving Bed Evaporator liquid feed system can be used to scavenge mercury vaporized by steam gasification of mixed wastes.

FY 1994 Budget: \$500K

Major Milestones:

• Complete mid-year progress report - March 31, 1994.• Complete final report - September 30, 1994.

6.3.3 Bio-Catalytic Destruction of Nitrate and Nitrite

Principal Investigator: D. Chaiko, ANL

Work Statement

The purpose of this task is to develop and demonstrate a technology for the reduction of nitrate and nitrite to elemental nitrogen and water. The reduction reaction will be carried out using purified reductase enzymes that are immobilized onto a solid support, providing a very high specific surface area. The reducing equivalents are provided by a low-voltage electrical current, which transfers electrons from the cathode to the enzymes via an electron transfer dye. The use of enzymes enables very large specific catalytic activity to be obtained without the need for additional chemical reagents or the production of secondary waste streams. An aqueous biphasic system is used to protect the enzymes from inactivation by electrolytes, while simultaneously allowing the transfer of nitrate to nitrite from the waste stream to the catalytic chamber.

FY 1994 Budget: \$350K

Major Milestones:

- Characterize target waste stream - December 15, 1993.
- Specify treatment process - December 31, 1993.
- Identify industrial/university partners - February 28, 1994.
- Complete final report - September 30, 1994.

6.4 Supercritical Water Oxidation Program (SCWO)

6.4.1 Dual Shell Reactor Vessel

Principal Investigator: B. Robertus, PNL

Work Statement

Modify the existing CRADA between Battelle Pacific Northwest Laboratories and Innotek Corporation to test the feasibility of the dual-shell pressure balanced vessel (DSPVB) for SCWO applications. The DSPVB will be designed for incorporation into an existing SCWO bench- or pilot-scale system. Test plan development and support in defining feed stocks will be coordinated through the SCWO Program Office.

All activities will be conducted in accordance with the SCWO Program Management Plan. All test plans will be submitted to and approved by DOE-HQ and the SCWO Program Office prior to finalizing.

FY 1994 Budget: \$225K

Major Milestones:

- Complete test plan - March 15, 1994.
- Complete tests with water only - April 29, 1994.
- Complete tests with organic + air/oxygen - August 30, 1994.
- Complete report on system testing - September 30, 1994.

6.4.2 Design Models for Supercritical Water Oxidation Corrosion Studies

Principal Investigator: N. French, SNL

Work Statement

The following tasks will be conducted under this activity:

- Coordinate with the SCWO Program Office to define model requirements and waste streams selection
- Develop an SCWO reactor model for determining operational parameters that minimize corrosion while assuming complete organic destruction. This task will include the development of an applications oriented chemical/thermal model of the reactor
- Utilize previously developed models and supported software as much as practical.
- Determine if a plug flow model is adequate for the SCWO process or if a more complete model may be required
- Provide verification and validation and code documentation per NQA-1 requirements. Independent validation will be conducted by the SCWO program
- Work with the SCWO Program Office to define the requirements for solids sub-model development to ensure they directly support the Hazardous Waste Pilot-Plan (HWPP) Demonstration Project.

All activities will be conducted in accordance with the SCWO Program Plan and all applicable laws and regulations. All tests plans shall be submitted to DOE-HQ and the SCWO Program Office for approval prior to finalizing.

FY 1994 Budget: \$205K

Major Milestones:

- Complete all HWPP regulatory documentation - June 30, 1994.
- Complete HWPP design (Model Development Corporation - MODEC) - August 1, 1994.
- Conduct corrosion testing - August 30, 1994.

6.4.3 Supercritical Water Oxidation Technical Support

Principal Investigator: R. E. Mesmer, ORNL

Work Statement

The following tasks will be conducted under this activity:

- Utilize the Cooperative Research and Development Agreement (CRADA) between the Oak Ridge National Laboratory and Model Development Corporation (MODEC) to evaluate MODEC's proprietary methods for neutralizing acids in situ without plugging the reactor with inorganic solids.
- Evaluate the behavior of the inorganic constituents in various wastes to make laboratory measurements of solubilities of potentially useful inorganic materials.
- Utilize the MODEC CRADA to conduct pilot studies of these corrosion and deposition control strategies.
- Incorporate properties of representative inorganics important to the performance of SCWO plants into models of solution chemistry appropriate for SCWO system operation.
- Utilize MODEC and the SCWO program office to evaluate potential problems, incorporate results into engineering codes, and perform experimental verification and testing of models.

All model development efforts shall be coordinated with SCWO program modeling activities at the Idaho National Engineering Laboratory (INEL), consistent with required protection of CRADA information.

All activities will be conducted in accordance with the SCWO Program Plan and all applicable laws and regulations. All test plans shall be submitted to DOE-HQ and the SCWO Program Office for approval prior to finalizing.

FY 1994 Budget: \$350K

Major Milestones:

• Conduct modeling meeting with INEL - November 30, 1993.• Complete tests on other neutralizers - September 30, 1994.• Complete upgrade of ASPEN database - September 30, 1994.

6.4.4 Supercritical Water Oxidation Demonstration Program

Principal Investigator: J. Beller, INEL

Work Statement

This activity will involve planning, coordination, and development activities to support demonstration of a supercritical water oxidation treatment pilot plant for mixed waste. This effort will be undertaken in two phases: 1) scale-up of the 30 gal/d unit to a 300 gal/d unit and tests on that unit to collect data for designing a SCWO unit for mixed wastes, and 2) design, build, and demonstrate a SCWO unit for mixed wastes.

FY 1994 Budget: \$4680K

Major Milestones:

- Initiate mixed waste pilot plant conceptual design - April 1, 1994.
- Complete hazardous waste pilot plant design - August 1, 1994.
- Start operations of hazardous waste pilot plant - July 31, 1995.

6.5 Technology Development Partnerships

6.5.1 Catalytic Wet Oxidation Process

Principal Investigator: P. Dhooge, Delphi Research

Work Statement

This activity will develop and demonstrate a catalytic wet oxidation process for treating multi-component wastes. The process also has potential to destroy hazardous organic compounds while containing and concentrating metals from contaminated materials. The process utilizes a patented combination of iron ions, a homogeneous oxidation catalyst, and a ferrous iron-to-ferric iron oxidation catalyst in an acid solution to oxidize organic compounds. This method may be used on a wide variety of waste types and on wastes dispersed in an inert matrix such as soil.

FY 1994 Budget: \$479K

Major Milestones:

- Complete organic, inorganic and soils tests - July 1, 1993.
- Complete engineering and cost studies - November 1, 1993.
- Complete Phase I report - January 30, 1994.
- DOE decision to start Phase II - February 15, 1994.

6.6 Miscellaneous

6.6.1 Ion Exchange at TNX Using the SKID Unit

Principal Investigator: J. P. Bibler, M. L. Meyer, WSRC

Work Statement

A skid-mounted ion exchange unit at the SR TNX facility will be used to demonstrate cesium removal using a resorcinol-formaldehyde resin. This system is a potential second generation process for decontamination of liquid streams at SRS, ORNL, and Hanford. Testing will determine resin friability and hydraulic properties as well as cesium removal efficiency in liquid streams from each of the 3 DOE sites.

FY 1994 Budget: \$1500K

Major Milestones:*

- Report water testing of SKID system - April 30, 1994.
- Report testing using ORNL simulant - May 31, 1994.
- Report testing using SR simulant - July 31, 1994.
- Report testing using Hanford simulant - September 30, 1994.

*(Note: As of mid-January, the Principal Investigator reports that due to funding delays, these milestones will be delayed at least 2-3 months.)

6.7 Activity Table

Table 6.1 lists the planned activities and budgets for the pretreatment activities.

Table 6.1. Activities Related to TWRS - Pretreatment

	Performing Organization	Budget
Underground Storage Tank Integrated Demonstration (UST-ID)		
Compact Process Unit	PNL	1500
Cesium Extraction	WSRC	200
Comprehensive Demonstration of Sludge and Supernate Processing	ORNL	1400
Technical Interchange with CEA	ORNL	350
TRUEX Validation and Data Collection	ORNL	125
Clean Option Support	ORNL	300
Organics Destruction Process Development	ORNL	100
TRUEX Model Development	ANL	300
Mobile Evaporator Concentrator	ANL	600
		<hr/> 4875
Efficient Separations and Processing Integrated Program (ESP-IP)		
Alkaline Tank Sludge Treatment	PNL	600
Develop and Test Sorbents	PNL	2150
Significant Volume Reduction of Tank Waste by Selective Crystallization	WHC	300
Fission Product Separation Using Ion Exchange, Solvent Extraction and CODCB	LANL	850
Solid Sequestering Agent; Removal of Transuranics	LANL	900
Aqueous Biphasic Systems: Radioactive Waste Pretreatment	ANL	350
Advanced Processing for Clean Option	ANL	400
In-Situ Magnetically Assisted Chemical Separation (MACS)	ANL	350
Sludge Washing and Dissolution of ORNL MVST Waste	ORNL	2050
Crystalline Silicotitanate for Cs/Sr Removal	SNL	675
Development and Evaluation of Electrochemical Methods of Destroying Nitrates and Organics	WSRC	850
		<hr/> 9475
Mixed Waste Integrated Program (MW-IP)		
Freeze Crystallization Technology for Concentrating and Partitioning Liquid Waste	WHC	600
Stream Reforming to Destroy Organic Materials and Nitrates	SNL	500
Bio-Catalytic Destruction of Nitrate and Nitrite	ANL	350
		<hr/> 1450

Table 6.1. (contd)

	Performing Organization	Budget
Supercritical Water Oxidation Program (SCWO)		
Dual Shell Reactor Vessel	PNL	225
Design Models for Supercritical Water Oxidation Corrosion Studies	SNL	205
Supercritical Water Oxidation Technical Support	ORNL	350
Supercritical Water Oxidation Demonstration Program	INEL	4680
		<u>5460</u>
Technical Development Partnerships		
Catalytic Wet Oxidation Process	Delphi	479
Miscellaneous		
Ion Exchange at TNX Using the SKID Unit	WSRC	<u>1500</u>
EM-50 Pretreatment Total		<u>23239</u>
 Subtotals		
	PNL	4475
	WHC	900
	LANL	1750
	SNL	1380
	INEL	4680
	ANL	2350
	WSRC	2550
	ORNL	4675
	Others	<u>479</u>
Balanced Total		<u>23239</u>

7.0 High-Level Waste Vitrification

7.1 Efficient Separations and Processing Integrated Program (ESP-IP)

7.1.1 Pyrochemical Treatment of ICPP High-Level Waste Calcine: Continue Development

Principal Investigator: T. A. Todd, INEL

Work Statement

Establish feasibility of pyrochemical process. Transfer to EM-30 after FY 1994; test separation bases on volatilization of chlorides and oxide solubilities in molten salt.

FY 1994 Budget: \$700K

Major Milestones:

- Determine Cs and Cd separation factors and recovery methods - March 30, 1994.
- Complete calcine volatility separation and recovery tests on actual calcine - August 31, 1994.
- Complete molten salt reduction tests for actinide and Sr removal - August 31, 1994.
- Complete halide volatility tests to determine Zr, Al, and B removal efficiencies - July 31, 1994.
- Issue Technology Status Report and go/no-go decision on integrated process DT&E - September 30, 1994.

7.2 Activity Table

Table 7.1 lists the planned activities and budgets for the high-level waste vitrification activities.

Table 7.1. Activities Related to TWRS - HLW Vitrification

	Performing Organization	Budget
Efficient Separations and Processing Integrated Program (ESP-IP)		
Pyrochemical Treatment of ICPP HLW Calcine:		
Continue Developement	INEL	<u>700</u>
EM-50 HLW Vitrification Total		<u>700</u>

8.0 Low-Level Waste Treatment

8.1 Underground Storage Tank Integrated Demonstration (UST-ID)

8.1.1 Biodentrification

Principal Investigator: G. F. Andrews, EG&G

Work Statement

The purpose of this activity is to develop biological processes for nitrate destruction and biosorption by initiating laboratory tests using appropriate waste simulants. Using spent biomass, complete an assessment of spent biomass adsorption capabilities and report the mass balance of the process, the quantity of biomass versus waste reduction, and potential destruction of the biomass waste. The design of the large laboratory-scale process will be updated to 2 kg of salt per day. The objective is to show how the technology can be moved into the field in 3 years.

FY 1994 Budget: \$300K

Major Milestones:

- Issue letter report on capabilities of spent biomass - January 31, 1994.
- Complete metalbiosorption/precipitation studies - June 30, 1994.
- Update design of the large-scale laboratory process - August 31, 1994.
- Complete continuous laboratory reactor tests for biodentrification - September 30, 1994.

8.1.2 Nitrate to Ammonia and Ceramic (NAC) Process

Principal Investigator: Mattus, ORNL

Work Statement

Efforts in FY 1994 will be focused on creating a strategic development plan and identifying, prioritizing, and performing laboratory-scale research needed to support scaleup of the NAC process to a cold demonstration of the process. The cold demonstration will be designed to generate data needed for further development of the NAC process. Design and fabrication of the cold demonstration experiment will proceed concurrently with laboratory-scale work to the extent practicable. Technical guidance will be provided to Florida International University as needed.

FY 1994 Budget: \$1700K

Major Milestones:

- Complete status report on NAC - September 30, 1994.

8.2 Mixed Waste Integrated Program (MW-IP)

8.2.1 Emerging Technology Systems Integration

Principal Investigator: J. J. Ferruda, ORNL

Work Statement

This activity will use a team of industrial and DOE-complex process engineers to analyze flowsheets developed by a computer-based process synthesis system. The process synthesis subtask will develop a systematic, computer-based system built on accepted methods for rapidly configuring and analyzing flowsheets. The systems analysis subtask will analyze flowsheets for mixed waste treatment that incorporates emerging and innovative technologies and will synthesize flowsheets based on available technologies. The emerging technology system team will develop and evaluate conceptual flowsheets for alternative process subsystems that use emerging innovative technologies for mixed waste treatment. The team will define a set of evaluation criteria, identify sequence of unit operations, obtain data, and analyze results of the systems analysis subtask.

FY 1994 Budget: \$575K

Major Milestones:

- Develop process synthesis tool - February 28, 1994.
- Produce vitrification process flowsheet - May 31, 1994.
- Produce steam reforming process flowsheet - June 30, 1994.
- Produce fixed hearth plasma arc process flowsheet - September 30, 1994.

8.2.2 Mixed Waste Vitrification Process Limits and Effluent Characterization

Principal Investigator: R. Peters, PNL

Work Statement

This task will determine the vitrification process envelope for three actual waste streams. The three proposed streams are residual ashes from the incinerators at Oak Ridge, from the incinerators at Los Alamos, and from the fluidized-bed incinerator at Rocky Flats. The selection of these wastes for vitrification development will be confirmed with the Mixed Waste Integrated Program (MW-IP) manager. The process envelopes will be defined in terms of waste stream compositional variability, glass forming additives, and the limits of incorporation of troublesome species. Troublesome species include heavy metals, halides, mercury, sulfur oxides, nitrogen oxides, organic liquids, and combustible solids as dictated by the probability of their presence in the waste streams of interest. Some sites (INEL, Hanford, Pantex) are considering thermal treatment alternatives such as direct vitrification of combustibles, rather than incineration followed by vitrification. This approach will be explored in preliminary scoping tests in bench- or pilot-scale units.

FY 1994 Budget: \$800K

Major Milestones:

- Select waste streams - November 1, 1993.
- Produce mid-year report - March 31, 1994.
- Complete final report - September 30, 1994.
- Complete process boundary report - September 30, 1994.

8.2.3 Phosphate-Bonded Ceramics for Stabilizing Problem Low-Level Mixed Waste

Principal Investigator: A. Wagh, D. Singh, J. Cu, ANL

Work Statement

The goal of this activity is to develop chemically bonded ceramics (CBCs) for low-temperature treatment and stabilization of DOE "problem" low-level mixed waste streams as identified by the MW-IP. Effort will be directed toward developing phosphate-bonded ceramics for treatment of solids and sludges containing contaminants such as liquid mercury, toxic metals, salt cakes, beryllium, and pyrophorics, and for mercury-contaminated aqueous liquids. In this project, final waste forms incorporating a wide range of simulated and actual wastes will be fabricated with optimal properties. Various factors involving the design and scaleup of the waste forms will be identified to assess the long-term performance of CBC final waste forms under field conditions.

FY 1994 Budget: \$300K

Major Milestones:

- Produce mid-year progress report - March 31, 1994.
- Produce final report - September 30, 1994.

8.2.4 Waste Form Performance Criteria

Principal Investigator: M. Fuhrmann, BNL

Work Statement

Two subtasks describe this activity, both of which will be performed by the working group for Criteria and Testing. In the first subtask the working group will provide technical support to the MW-IP by reviewing ongoing programs and providing guidance for the call for proposals. It will also give input to the MW-IP for the mid-year reviews and if necessary for outside peer reviews of MW-IP projects. The objective of the second subtask is to supplement the work performed in FY 1993 in development of Waste Form Performance Criteria and Testing/Evaluation methods for Mixed Waste. Input from ASTM, other areas of DOE (EM-30 and EM-40), and EPA on the Waste Form Performance Criteria document will be sought and evaluated, and the criteria document will be revised as necessary.

FY 1994 Budget: \$180K

Major Milestones:

- Present waste form performance criteria and tests to ASTM committee - December 31, 1993.
- Present waste form performance criteria and tests to EM - February 15, 1994.
- Complete performance criteria document - July 15, 1994.

8.2.5 Low-Level Mixed Waste Vitrification Process Limits

Principal Investigator: D. F. Bickford, WSRC

Work Statement

This project outlines the development of "Vitrify to Dispose" technology by establishing the processing envelope for specific waste streams that lend themselves to treatment by vitrification and are representative of a large portion of DOE complex waste. MW-IP has selected three specific wastewater treatment sludges that meet these requirements: 1) Oak Ridge Y-12 sludge ($> 1\%$ organics, 154 m^3 inventoried) uniqueness-organics, 2) LANL sludge ($< 1\%$ organics, 154 m^3 inventoried) uniqueness-likelihood of success, and 3) Rocky Flats sludge ($< 1\%$ organics, 3 m^3 inventoried) uniqueness-nitrates. In addition, several specific fly ash streams will be phased in as time permits. The actual waste streams are controlled air incinerator ash from LANL and TSCA incinerator ash from ORNL. However, the work on the wastewater sludges will be completed before work commences on the ashes. A major deliverable of this effort will be a delisting plan for use of vitrification processing to delist DOE mixed waste. This plan will include an example containing data obtained on the above-mentioned waste streams. The plan will serve as a guide to waste operations personnel.

FY 1994 Budget: \$2100K

Major Milestones:

- Complete test plan for ash - November 30, 1993.
- Produce advanced melter report - December 31, 1993.
- Produce report on compositional glass limits - June 30, 1994.
- Complete advanced melter comparison - August 31, 1994.
- Complete delisting plan - November 30, 1994.
- Produce final report - September 30, 1994.

8.3 Minimum Additive Waste Stabilization Program

8.3.1 High-Temperature MAWS Systems Evaluation

Principal Investigator: I. Pegg, ANL and CUA

Work Statement

The main goal of this activity will be to identify promising technologies and evaluate them in a systematic way at various bench-scale levels as required in preparation for a pilot-scale test at a selected DOE site. It is anticipated that potential melter systems will be chosen from technologies including plasma, microwave, metal melt, and high-temperature joule-heated configurations. Specific technologies or configurations not being given serious consideration by other EM-50 offices will be emphasized (where possible) to minimize duplication of efforts. From that list, two technologies will be chosen for initial lab-scale demonstration studies at Catholic University or other qualified parties.

It is expected that the development process will proceed in phases. The first phase will be initiated in FY 1994 and will involve bench-scale studies. The initial lab scale operation will include appropriate off-gas treatment and sampling systems. The studies may include additional crucible melt studies only if necessary to support potential feed compositions which will broaden the compositional envelope. The developmental status of the selected technology will determine the type (radioactive or nonradioactive testing) and the scale of testing to be conducted. Detailed off-gas data should be generated versus operating conditions to determine special treatment needs, and preliminary cost/benefits in a MAWS approach accessed.

The second phase will be to select one of the two technologies for scaleup to the next appropriate size. This decision will be based on technical and economic cost/benefit analyses from the first testing phase. Continued testing on the phase I unit will only be carried out if such data can not be obtained from the phase II testing unit or not as cost effective. This larger scale unit should consider feed preprocessing requirements such as size reduction/beneficiation/incineration. It should provide detailed off-gas system performance as a function of operating parameters for a variety of actual radioactive wastes from suitable DOE sites. Data gathered should enable technical and economical evaluation for a decision on whether to proceed to pilot scale operation at a selected DOE site.

FY 1994 Budget: \$1440K

Major Milestones:

- Complete technology selection for study - December 31, 1993.
- Select one technology for further scaleup to next size - October 31, 1994.
- Complete testing of two high-temperature systems - December 31, 1994.

8.3.2 Glass Compositional Envelope Study

Principal Investigator: I. Pegg, CUA

Work Statement

The objective of this study is to provide waste-glass forming information and data to guide, focus, and expedite development studies required for new waste streams, reduce overall development cost, and reduce cycle time from waste characterization to technology implementation. This glass composition envelope information would permit identification of optimal formulations and a rapid evaluation of the applicability and potential benefits of the MAWS technology for any given remediation problem.

A series of crucible melts will be carried out which will expand the compositional envelope for acceptable glasses using real wastes and soils from various DOE sites. Glass samples from the crucible melts will be characterized as to composition and processability in various melter configurations. In addition the glasses will be subjected to various leach tests to determine their long term durability characteristics. Models will be developed to aid in predicting performance of other non-tested compositions within the window/s of study.

FY 1994 Budget: \$1400K

Major Milestones:

- Complete selection of waste streams - December 31, 1993.
- Deliver waste samples - January 31, 1994.
- Complete waste characterization - April 1, 1994.
- Complete crucible melts with real wastes - March 30, 1995.
- Complete durability tests - September 30, 1995.

8.3.3 Minimum Additive Waste Stabilization (MAWS) Phase II

Principal Investigator: I. Pegg, GTS Duratek

Work Statement

The objective of the MAWS program is to demonstrate a system which, through the treatment and blending of multiple waste streams, results in a minimum additive stabilization process. The demonstration is being conducted at the Fernald Environmental Management Project (FEMP) in Fernald, Ohio. The program schedule provides for operation of a production scale soil washing and water treatment system and on-site vitrification demonstration at a rate of about 300 kg/day as finished glass. The goal is to develop the operational parameters necessary to further validate the process and scale it up to commercial treatment of the wastes. The operations will use actual radioactive wastes streams from on-site and will conduct full evaluations of produced glass to determine quality and durability to potentially justify a delisting petition. At the completion of the testing and validation runs the equipment will be disassembled and inspected for erosion/corrosion wear of parts and any buildup within the system.

FY 1994 Budget: \$2700K

Major Milestones:

- Complete radioactive runs on 300 kg/d melter - March 31, 1994.
- Complete soil washing operations (100 cuyd) - March 31, 1994.
- Submit melter operational envelope definition - May 31, 1994.
- Complete erosion/corrosion inspection of melter - June 30, 1994.
- Issue final report on project - July 31, 1994.

8.3.4 Glassy Slag Composition Envelope Study

Principal Investigator: X. Feng, ANL

Work Statement

The objective of this study is to utilize slag waste forms to expand the range of waste stream mixtures that can be treated using the MAWS technology beyond those known to produce acceptable glasses. Compositional ranges for waste streams appropriate for the production of slag waste forms will be identified. The ranges will be developed through a series of crucible melts using both simulated and real wastes/soils. Appropriate waste streams would include those which have low amounts of fluxing agents and high oxidizable metal contents. Metals considered will include Al, Cu, Pb, Sn, Ti, Ca, Mg, Fe, Cr, Ni, Zn, and Zr.

Appropriate characterization as well as waste form durability evaluation will be carried out on each slag waste form to determine its leach resistance and ability to resist undergoing surface phase alteration. This information will be used to further develop and refine chemical composition models which can predict waste durability and compatibility in various slag and glass waste forms.

FY 1994 Budget: \$380K

Major Milestones:

- Complete waste stream data screening - December 31, 1993.
- Complete crucible melt studies - September 30, 1994.
- Complete compositional model development - November 30, 1994.
- Submit final report - December 31, 1994.

8.4 Buried Waste Integrated Demonstration (BW-ID)

8.4.1 BW-ID Graphite Direct Current Arc Plasma

Principal Investigator: J. E. Surma, PNL

Work Statement

This task involves the continued development of the graphite electrode DC arc technology for the treatment of mixed transuranic (TRU) contaminated buried wastes and soils. A three-way partnership has been established among the Pacific Northwest Laboratory (PNL), Massachusetts Institute of Technology (MIT), and Electro-Pyrolysis Inc. (EPI) to conduct this development activity. In FY 1994, the deliverables will include a thorough evaluation of the graphite electrode DC arc plasma process for BW-ID wastes based upon tests using the Mark II DC arc plasma technology. The development of a set of diagnostics to fully characterize and evaluate the plasma process will also be carried out in FY 1994. The work will support the efforts and goals of the BW-ID and will also be applicable for demonstrations in other IDs. A close coordination of this work with other BW-ID and MW-IP activities is already ongoing.

FY 1994 Budget: \$970K

Major Milestones:

- Complete series I Mark II testing - April 1, 1994.
- Complete series II Mark II testing - September 1, 1994.
- Produce draft final report on Mark II testing - September 1, 1994.
- Produce final report on diagnostics program - September 1, 1994.

8.5 Technology Development Partnerships

8.5.1 Fossil-Fired Vitrification

Principal Investigator: J. S. Patten, Vortec Corp

Work Statement

An innovative fossil fuel-fired vitrification process for remediation of soils containing hazardous and/or radioactive constituents is being developed. This process is an extension of an advanced multi-fuel-capable combustion and melting technology being developed for commercial glass manufacturing and waste processing/recycling with funding support from DOE and the EPA. The unique features of this technology provide the potential for a cost-effective and environmentally safe process for vitrification of sediments, soils, sludges, and mill tailings containing organic, metallic, or radioactive contaminants.

FY 1994 Budget: \$533K

Milestones:

- Complete sub-scale testing - September 28, 1993.
- Complete Phase I report - January 31, 1994.
- DOE decision to start Phase II - February 15, 1994.

8.6 Activity Table

Table 8.1 lists the planned activities and budgets for the low-level waste treatment activities.

Table 8.1. Activities Related to TWRS - LLW Treatment

	Performing Organization	Budget
Underground Storage Tank Integrated Demonstration (UST-ID)		
Biodentrification	EG&G	300
Nitrate to Ammonia and Ceramic (NAC) Process	ORNL	1700
		<u>2000</u>
Mixed Waste Integrated Program (MWIP)		
Emerging Technology Systems Integration	ORNL	575
Mixed Waste Vitrification Process Limits and Effluent Characterization	PNL	800
Phosphate-Bonded Ceramics for Stabilizing Problem Low-Level Mixed Waste	ANL	300
Waste Form Performance Criteria	BNL	180
Low-Level Mixed Waste Vitrification Process Limits	WSRC	2100
		<u>3955</u>
Minimum Additive Waste Stabilization Program		
High Temperature MAWS Systems Evaluation	ANL/CUA	1440
Glass Compositional Envelope Study	CUA	1400
Minimum Additive Waste Stabilization (MAWS) Phase II	Duratek	2700
Glassy Slag Composition Envelope Study	PNL	380
		<u>5920</u>
Buried Waste Integrated Demonstration (BW-ID)		
BW-ID Graphite Direct Current Arc Plasma	PNL	970
Technical Development Partnerships		
Fossil Fired Vitrification	Vortec	533
		<u>533</u>
EM-50 LLW Treatment Total		<u>13378</u>
Subtotals		
	PNL	2150
	ORNL	2275
	BNL	180
	ANL	1740
	WSRC	2100
	Others	4933
Balanced Total		<u>13378</u>

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