THE FERNALD POST CLOSURE STEWARDSHIP TECHNOLOGY PROJECT AND INTEGRATING STEWARDSHIP TECHNOLOGY TEAM – PROGRESS IN THE IDENTIFICATION, IMPLEMENTATION, AND DEMONSTRATION OF MONITORING TECHNOLOGY FOR POST CLOSURE STEWARDSHIP

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ABSTRACT

This paper will describe how the Fernald Environmental Management Project (Fernald) has begun to address its post-closure stewardship technology needs through the formation and workings of the Post Closure Stewardship Technology Project (PCSTP) and its associated Integrating Stewardship Technology Team (ISTT). The Fernald PCSTP was formed to identify the site's post-closure stewardship technology needs, recommend technologies to satisfy those needs, design and engineer long-term monitoring systems, demonstrate and deploy monitoring technologies, and provide consulting services to Fernald project managers and engineers. The PCSTP was modeled after a team concept devised by the Deactivation and Decommissioning Focus Area (DDFA) and employed successfully during the Fernald Large Scale Demonstration and Deployment Project in 1997. The DDFA's recipe for an effective team calls for the integration of local stakeholders; regulators; project mangers; DOE personnel from the Site, Focus Area, and Headquarters; project managers from the site's managing contractor; and world-renowned experts in the fields of focus. In developing the PCSTP, Fernald applied this team concept to the ISTT, a sub-group that carries out the Project's major tasks. ISTT members operate under the direction of Fernald project management to perform tasks such as researching specific technologies, engineering post-closure monitoring systems, and coordinating the development of data collection parameters. The information in this paper will serve as a guide and learning tool in the formation of effective teams and processes for sites that will soon be facing the challenges of designing and implementing monitoring systems for post-closure stewardship.

BACKGROUND

Post-closure Stewardship – Post-closure stewardship encompasses the activities and use restrictions that are necessary to protect human health and the environment following environmental remediation activities at DOE Environmental Management (EM) sites. Activities and use restrictions include the physical controls, institutions, and other mechanisms needed to ensure protection of the community and the environment. It is anticipated that post-closure stewardship will be needed at more than 100 DOE sites after DOE's EM program completes disposal, stabilization, and restoration operations to address waste and contamination resulting from 50 years of nuclear research and nuclear weapons production. DOE is required to conduct stewardship activities under existing requirements, and many DOE organizations have been conducting stewardship activities over the years as part of their ongoing missions. Scientists and engineers have long understood that much of the waste and other materials managed by DOE cannot be broken down into non-hazardous materials. These materials must be managed by treatment, isolation, and monitoring.

A variety of hazards will remain at many DOE sites after these sites have been cleaned up to agreed-upon levels. Residual hazards will remain in four categories of media: engineered units, soil and buried waste, facilities, and water. In some cases, cleanup reduces risk but may not be able to reduce contaminant concentrations to levels deemed safe for unrestricted site use. The need for stewardship at DOE sites results largely from the radioactive contaminants that will remain onsite and continue to pose some degree of risk indefinitely after cleanup is complete.

Post-closure stewardship activities are also performed on a complex and site wide level depending on the nature of the site conditions and/or the residual hazards. General requirements for site stewardship are prescribed by statute; additional guidelines for implementing these requirements are contained in regulations and DOE directives. These activities vary in supporting and evaluating new technologies that may be useful in characterizing environmental and health impacts of residual contaminants, reducing post-closure stewardship costs, improving remedy performance, or providing a permanent remedy that obviates the need for post-closure stewardship at certain sites.

Other federal agencies that acknowledge post-closure stewardship responsibilities are: the Environmental Protection Agency (EPA), the Department of Defense (DOD), and the Department of the Interior (DOI). While they may not have to contend with radiological contamination, their approach to the challenges of post-closure stewardship is similar to the approach taken by the DOE. Each organization is utilizing or proposing to utilize similar baseline technologies, if they exist, to ensure protection of people and the environment at sites where cleanup has been completed.

Post-closure stewardship is a relatively new challenge faced by the DOE. Some of the baseline stewardship technologies are labor-intensive (e.g., groundwater monitoring), while others have recognized uncertainties (e.g., degradation of engineered units or facilities). The DOE is addressing these concerns by searching for, selecting, demonstrating, and facilitating the deployment of technologies that require less labor, are lower in cost, reduce exposure of personnel to radioactive and other hazardous materials, and minimize or eliminate uncertainties. At Fernald, innovative technologies will be demonstrated and deployed to provide the DOE, regulators, and stakeholders with the assurance that the site and its facilities are secure and performing as designed.

At Fernald, the PCSTP is responsible for searching for, selecting, demonstrating, and deploying cost-effective and safe technologies to perform post-closure stewardship at Fernald. The baseline activities utilized for post-closure stewardship, if they currently exist, are organized into two categories: active and passive controls. Active controls require that certain activities to control risk at a site be performed on a relatively frequent or continuous basis. These activities can include operating, maintaining, and monitoring the engineered controls implemented at the Fernald site, including caps, other physical barriers, and groundwater pump-and-treat systems. Examples of active controls are collecting water samples and repairing fences and erosion gullies. Passive controls include less intensive tasks that convey information about site hazards and/or limit access through physical or legal means. Examples of passive controls are physical systems (fences and other barriers), government controls, and proprietary controls.

INTRODUCTION

While environmental remediation at Fernald is nearing completion, technology needs in the arena of post closure stewardship continue to emerge at the site. The PCSTP was founded and developed to meet these needs. A former uranium processing facility, Fernald has been the site of environmental remediation for over a decade. Significant progress has been made in the cleanup of Fernald and the surrounding area, and long-term post-closure monitoring is needed to ensure that environmental quality is maintained. Fernald is one of the first DOE closure sites to actively pursue a long-term stewardship strategy; and it is the only site to have begun installing a post-closure monitoring system for a facility, known as the On-Site Disposal Facility (OSDF) that will remain after closure. The OSDF, an engineered structure composed of a multi-layer cap and liner system, will permanently store mildly contaminated soil and construction debris. The wastes designated for the OSDF are not hazardous enough to require off-site shipment to a radioactive waste disposal facility but still pose a contamination risk if the OSDF malfunctions. Advanced technologies are needed to monitor the integrity of the OSDF and its associated components and to predict any potential problems.

The work scope for this project will be executed by the ISTT, a team concept first developed at Fernald that represents a broad-based, objective approach to the evaluation and deployment of innovative technology. The ISTT is comprised of stakeholders, regulators, and experts in landfill design, engineering, and construction from the DOE, Fluor Fernald, and academic institutions. The team is responsible for researching, screening, demonstrating, and deploying post-closure stewardship technologies that meet site-specific needs. (See Figure 1 for an organization chart of the ISTT and Figure 2 for a flow diagram of the technology identification/selection/demonstration process).

The ISTT has identified initial technology needs in the areas of monitoring, leachate management, and data reporting (See Table I for detailed list). The ISTT is seeking technologies that can: **1)** accurately measure the key parameters selected as indicators of long-term OSDF performance; **2)** provide passive treatment of OSDF leachate flow; and **3)** facilitate efficient data collection, integration, management, interpretation, and reporting efforts.

Currently, the ISTT is focusing on the application of advanced technologies to meet the stewardship and monitoring needs of the OSDF and its associated components. Successful long-term maintenance and monitoring of the OSDF is of primary importance to regulators and stakeholders.

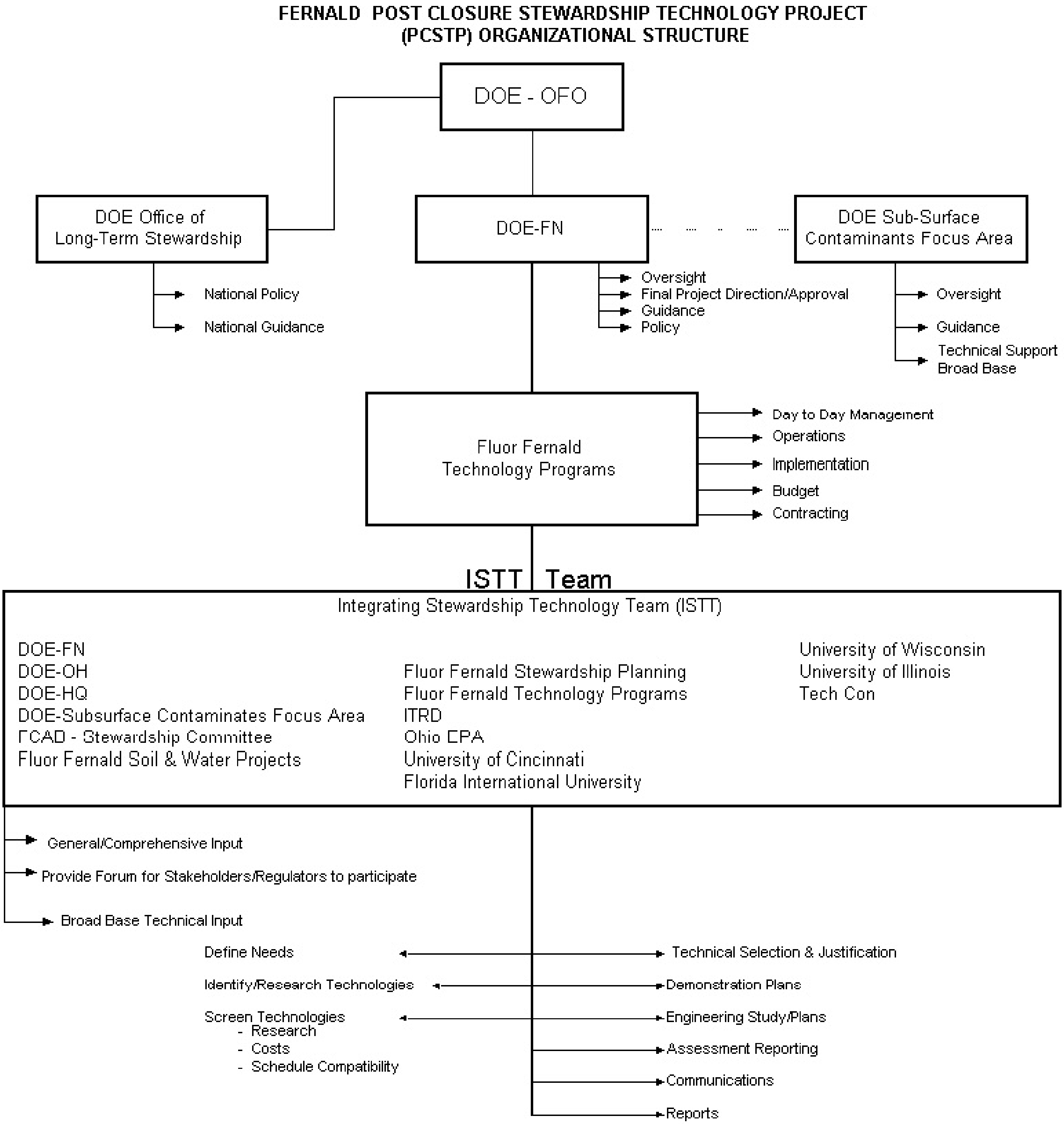

Fig. 1: PCSTP Organizational Structure

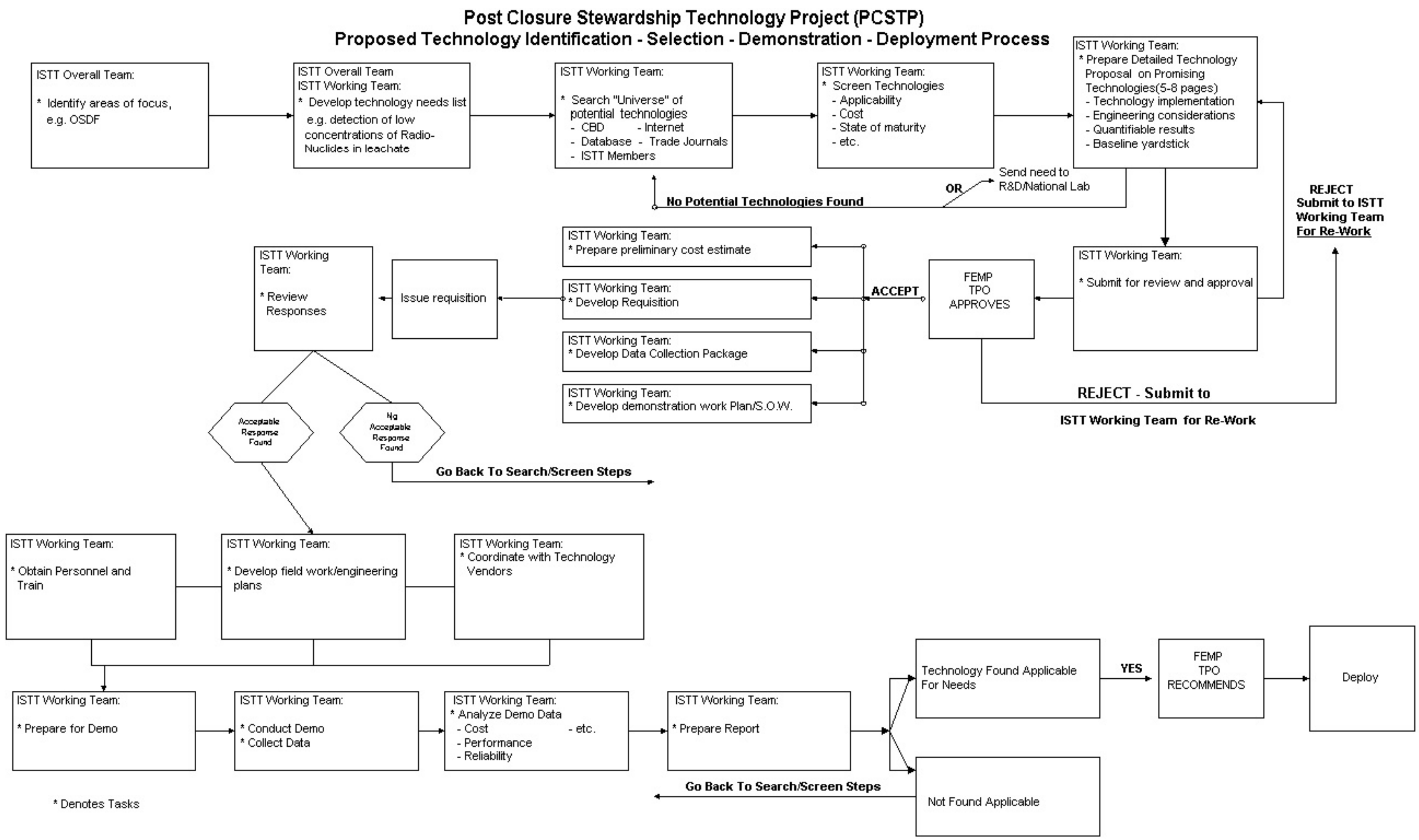

Fig. 2. Fernald PCSTP Technology Process

Table I. Initial Technology Needs Developed by the Fernald ISTT

CATEGORY		MEASUREMENT NEEDS
Monitoring	*Cover System Integrity*	Warning signs of uneven subsidence, surface erosion, burrowing animals, and slope failure or plugged drainage layer in cover system
	Leachate Flow/Quality	Cell-specific leachate flow rates and water quality indicators; technology to be installed inside OSDF Leak Detection System, Leachate Collection System, and Enhanced Permanent Leachate Transmission System
	Ground Water Quality	Underlying perched groundwater and Great Miami Aquifer quality, using a network of horizontal and vertical monitoring wells with remote sensing capabilities for radiological and chemical parameters under/around OSDF
	Health of Ecological Environment	Wildlife habitat and general health and diversity of vegetation
	Weather	Precipitation, temperature, wind, and seismic conditions
	Effectiveness of Institutional Controls	Conditions of access roadways, fences, signs, storm water management structures/channels, and other facilities accessible to the public
Leachate Management		Develop and implement a long-term passive treatment system for reduced leachate flow from the OSDF using geo-chemical and/or biological treatment technologies
Reporting		Establish integrated data and record repository that can provide timely, easy, and complete access to/interpretation of all historical information regarding OSDF design and construction, as well as any new monitoring data. Repository will be accessible by DOE, regulators, and stakeholders

FOCUS ON OSDF CELL 1 FINAL COVER MONITORING SYSTEM

After the ISTT had identified the initial post-closure stewardship technology needs, the Team decided to focus on the Cover System Integrity needs first because the first cell of the OSDF was slated for completion in fall 2001. Thus, there was a narrow window of opportunity to place monitoring technology into the final cover system of Cell 1. In order to correctly identify the critical monitoring parameters and monitoring technologies for Cell 1, the ISTT reviewed the drivers; performance expectations; design period; and design basis for the OSDF.

Drivers

Fluor Fernald identified the regulatory drivers for the OSDF by reviewing the applicable or relevant and appropriate requirements (ARARs) in the Records of Decision (ROD) for the Operable Units (OU) 2, 3, and 5. This review identified the ARARS that were related to on-site disposal. As the design and construction of the OSDF proceeds, the ARARs will be revised or updated, as needed. Drivers for the operation, monitoring, maintenance, and reporting of the OSDF include federal and state laws, regulations, and guidance, including the following:

- Department of Energy (DOE) Orders
- Standard building codes
- Ohio Solid Waste Regulations
- Ohio Hazardous Waste Regulations
- Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA)
- Federal Resource Conservation and Recovery Act (RCRA) Regulations
- Clean Water Act (CWA) Regulations and National Pollutant Discharge Elimination System (NPDES) program
- National Environmental Policy Act (NEPA)
- Uranium Mill Tailings Reclamation and Control Act (UMTRCA)
- Substantive permit requirements of: US Army Corps of Engineers (ACOE) Nationwide Permit for wetlands impacts, the Ohio Solid Waste Permit to Install (PTI), and the RCRA Permit

The potential exists for future requirements due to more stringent interpretations of current regulations and through the promulgation of new regulations. In addition, new and emerging landfill technologies may impact the development of additional requirements.

Performance Expectations

The performance expectations of the OSDF are as follows:

- to safely construct and operate the OSDF in a timely, efficient, and cost-effective manner;

- to comply with all associated ARARs;

- to be protective of human health and the environment;

- to accommodate the total volume of impacted material meeting the Waste Acceptance Criteria (WAC) from remediation of the Fernald Operable Units 2, 3, and 5 (estimated to be 2.5 million cubic yards);

- to be constructed, filled, and closed in phases for an active life of 7 to 25 years; and

- to have a design life of at least 200 years and up to 1,000 years to the extent reasonably achievable by:

- containing and collecting leachate;
- minimizing infiltration and stormwater runon/runoff damage;
- providing sufficient slope stability to withstand conditions throughout design life;
- minimizing erosion of soil layers; and preventing intrusion of plant roots and burrowing animals.

Design

The OSDF design is expected to operate over the life of the facility. Over time, the construction material properties may change. The following three primary periods have been defined:

- *Initial Period* - initial construction through the 30-year post-closure monitoring period;
- *Intermediate Period* - 30 years after final closure of the OSDF through at least 200 years and up to 1,000 years to the extent reasonably achievable;
- *Final Period* **-** the period during which the performance of the OSDF has stabilized to its permanent state, starting at least 200 years, and possibly up to 1,000 years, after final closure. The OSDF design configuration will allow decision makers at the start of the final period to select an appropriate final management strategy for the facility.

Design Basis

The objective and purpose of the OSDF project is to provide a permanent remedial solution for uranium-contaminated soil and debris. The OSDF project will contain approximately 2.5 million cubic yards of impacted contaminated material. When completed, its size will be approximately 3,700 ft x 800 ft, with a maximum height of 64 ft.

Cap, Liner, and Leak Monitoring Systems

The remediation strategy includes a multi-layer cap and liner system containing both natural and synthetic materials. The ultimate design basis for the cover and liner system is to maintain groundwater quality for 1,000 years. The OSDF cover system is a resistive barrier designed to limit percolation into the waste, resist the intrusion of biota, and separate the waste material from the surface environment. The hydraulic barriers consist of a geomembrane overlying a geosynthetic clay liner, which overlies a compacted soil barrier. The liner system is a double composite system, which includes a composite liner consisting of a geomembrane overlying a geosynthetic clay liner as the primary liner.

The purpose of the liner is to prevent leachate transport to the Great Miami Aquifer, which is a major source of drinking water. With respect to this, the cap and liner systems incorporate a leachate collection system. In addition, the liner includes a leak detection system, located below the leachate collection system, for the proper monitoring of any leaks from the liner. The collected leachate is analyzed by an automated in-line monitoring system. It is planned that grab samples will be collected and laboratory analyses will be performed to confirm or calibrate the in-line monitoring system results.

The primary objectives of the groundwater/leak detection and leachate monitoring program are twofold: (1) to prevent contamination of the Great Miami Aquifer by chemicals that might leak from the OSDF, should a leak occur, and (2) to provide information essential to the proper disposal of leachate, whenever such fluids are present. These objectives are to be met by a multifaceted system that will monitor select parameters in liquids sampled from both inside and outside the OSDF. The monitoring system includes a capability to collect samples from multiple sources, analytical techniques for analyzing the samples, procedures for treating the results, and an overall protocol of operation.

The leak detection monitoring program focuses on the best indicators of potential releases, rather than proposing to analyze for every possible constituent that may be present in the OSDF. This is a reasonable approach so long as the best indicators are easily identifiable. Fourteen primary parameters and four supplemental indicator parameters are proposed for initial groundwater leak detection monitoring of the OSDF. The Proposed Primary Parameters List includes two key radionuclides (Tc-99 and total uranium), ten organics, and two inorganics. The supplemental indicator parameters are pH, specific conductance, total organic halogens (TOX), and total organic carbon (TOC).

This system for detecting the appearance of leachate chemicals outside the OSDF will provide an immediate warning should leakage from the OSDF occur. The leak detection monitoring program employs a multi-component approach for leak detection, relying on the collective responses from four components:

1) leachate collection system (LCS) inside the OSDF;
2) leak detection system (LDS) inside the OSDF, but below the LCS (this system will collect any fluid that leaks through the primary liner);
3) perched groundwater monitoring component, which will be located immediately below the LDS and LCS sump for each cell (the lowest elevation point of each cell, which is considered to be the most likely location for a potential leak to originate);
4) Great Miami Aquifer monitoring component, which is found at depths ranging from 45 to 90 feet below the OSDF.

Construction Plan and Waste Placement

The OSDF will be constructed in phases, with eight individual cells and an additional contingency cell planned in order to accommodate Fernald's remediation waste. The benefits of constructing the OSDF as a series of contiguous cells include: limiting the time and area of liner system exposed to weathering, limiting the quantities of leachate and stormwater that must be handled, and reducing the initial capital expense.

The design of the OSDF maximizes the air-space available for disposal and minimizes the volume of leachate to be treated. Such design considerations go beyond regulatory concerns and result in the design and inclusion of significant components not addressed by regulations. Such non-regulatory components are essential for the economic operation of the facility.

Efficient waste placement and compaction practices will result in optimal use of the disposal cell capacity, favorably affecting the long-term economics of the project; minimize the void/channels through which water could travel; and control erosion.

Best practice calls for the elimination or containment of leachate to prevent contamination of the underlying groundwater aquifer. The use of clay and membrane liners has historically been the favored method of reducing or eliminating the percolation of leachate. Equally important in controlling the movement of leachate is the elimination of surface water infiltration, which is the major contributor to the total volume of leachate. Infiltration at the OSDF will be controlled through the use of stormwater run-on/runoff management, appropriate contouring, and a multi-layered capping system (infiltration barrier, drainage layer, biotic barrier, filter layer, and vegetative layer).

CRITICAL MONITORING PARAMETERS

After taking the above criteria into consideration, the ISTT worked to develop a set of critical monitoring parameters that would measure and reflect the functional requirements and design criteria of the OSDF and its cover system. For example, in reviewing the design criteria for the OSDF cover system, one of the primary requirements of the system is to limit the percolation of water into the waste. Therefore, the ISTT focused on those elements of the OSDF cover system that were designed to prevent the percolation of water into the waste, such as the parameter of head in the drainage layer. One would want to know whether this element of the cover system is performing according to design; if not, one would desire an early warning of potential problems. It was the ISTT's close examination of the functional and design requirements of the OSDF cover system, and the selection of parameters that could reliably and accurately be measured, which led to the list in Table II below. In addition to closely examining the OSDF's functional and design requirements, ISTT members were also able to call on their considerable years of experience, research, and expertise in developing the parameters. When selecting the monitoring technologies for the parameters, the ISTT considered a number of factors, including: cost, reliability, accuracy, ease of installation, and past experiences.

Table II – OSDF Cell 1 Final Cover Monitoring System Parameters, Critical Elements, and Technologies

Parameter	Critical Elements	Technology
Differential Settlement	Condition of barrier layer, maintenance of drainage	Topographic survey with settlement plates; Ground Penetrating Radar Targets
Head in Drainage Layer	Stability of cover system	Pressure Transducers
Drainage layer temperature, barrier temperature	Stability of cover system, frost protection of barrier layers	Thermistor embedded in transducer
Root zone status/Vegetative soil layer status	Erosion control	Water content reflectometers, heat dissipation units
Vegetative health & coverage	Erosion control	Topographic surveys, web cam, remote sensing

CURRENT STATUS

Fabrication of the instrument nests (pressure transducer risers, soil water status nests, and GPR plates) began in June 2001 after their engineering and design was completed. This work scope was completed by local, approved small businesses. Installation of the monitoring nests (in which the actual sensors will be placed) began in July 2001 and was performed by IT Corporation – the contractor constructing the Cell 1 final cover system. In anticipation of issuing an RFP for the procurement and calibration of specified monitoring instrumentation and associated equipment; technical oversight of monitoring system installation; and start-up and training, Fluor Fernald issued a Commerce Business Daily (CBD) announcement soliciting interested, qualified, small businesses. This announcement was posted on CBD's web site at http://cbdnet.access.gpo.gov/ (future CBD announcement soliciting expressions on interest for technology work associated with this project will also be posted here ~~too~~). In addition to the CBD announcement, e-mail notices announcing the ISTT's intentions were sent to a large list of technology providers and business via Tech Con (Tech Con is a member of the ISTT). To sign up and receive Tech Con's email and news releases, visit their web site at http://web.ead.anl.gov/techcon/. In September 2001, an RFP was issued to the qualified small business that had responded to the solicitations; subsequently, a contract was awarded to GeoSystems Analysis of Tucson, Arizona, to execute the specified scope of work.

Installation of the monitoring devices and equipment is currently underway, with the calibration and installation of the actual instruments scheduled to take place in January and February 2002. See Figure 3 for a look at the installation of a pressure transducer riser and plate and rod settlement device nest. The Cell 1 monitoring system is expected to be fully operational by Spring 2002. Once the system is installed, data will be collected according to the following monitoring schedule stated in the Post Closure Care and Inspection Plan:

- Monthly – At completion of each cap for at least two years
- Quarterly – During remaining OSDF construction period and for additional three years
- Annually – Three years after completion of OSDF construction

In 2002, the PCSTP will begin to address additional post-closure stewardship technology needs as funding allows. Potential need areas include: leachate quantity and quality monitoring, flow quality and quantity monitoring in the channel around the OSDF, passive leachate treatment, remote sensing of restored areas and the OSDF, remote sensing of the OSDF, and cover monitoring for OSDF Cell 2. To learn more about the PCSTP or to receive an update on current activities, please contact Kathi Nickel (Fernald DOE Technology Program Officer) at 513.684.3166 or kathi.nickel@fernald.gov, or Marty Prochaska (Principle Investigator for the PSCTP) at 513.648.6555 or marty.prochaska@fernald.gov.

The PCSTP's progress and accomplishments in stewardship planning and monitoring technology application establish the site as a pioneer within the DOE complex, which has focused primarily on site closure and remediation. Long-term stewardship is becoming an increasingly important issue to DOE closure sites, many of which will soon face their own post-closure monitoring and maintenance challenges. Fernald's experience with the OSDF and monitoring technologies will benefit sites that have not yet begun planning for long-term stewardship, as well as those which are beginning to encounter similar challenges.

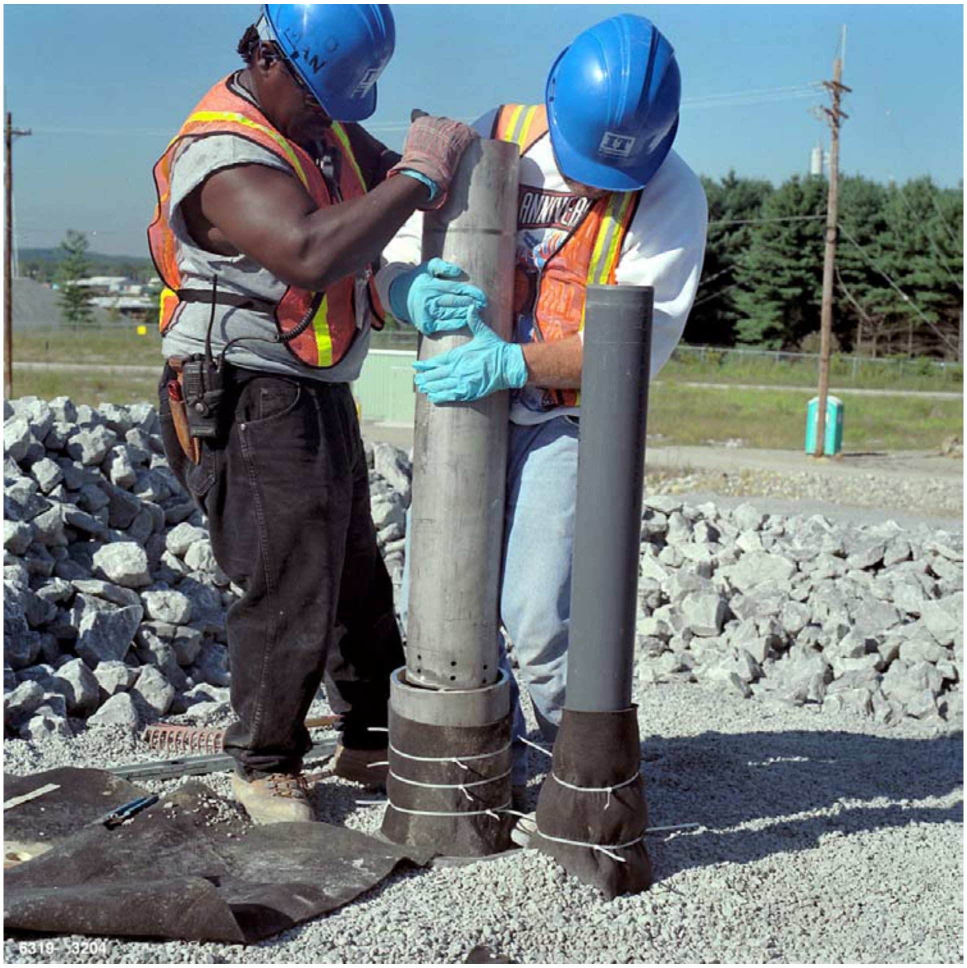

Fig. 3. Installation of Pressure Transducer Riser and Plate and Rod Settlement Nest