HANFORD SITE CLEANUP CHALLENGES AND OPPORTUNITIES FOR SCIENCE AND TECHNOLOGY – A STRATEGIC ASSESSMENT

Wayne Johnson, Barbara Reichmuth, Thomas Wood
Pacific Northwest National Laboratory
P.O. Box 999, MSIN K7-97, Richland, WA 99352

Marcus Glasper, James Hanson
U.S. Department of Energy, Richland Operations Office
P.O. Box 550, MSIN K8-50, Richland, WA 99352

ABSTRACT

In November 2000, the U.S. Department of Energy (DOE) Richland Operations Office (RL) initiated an effort to produce a single, strategic perspective of RL Site closure challenges and potential Science and Technology (S&T) opportunities. This assessment was requested by DOE Headquarters (HQ), Office of Science and Technology, EM-50, as a means to provide a site-level perspective on S&T priorities in the context of the Hanford 2012 Vision (1). The objectives were to evaluate the entire cleanup lifecycle (estimated at over $24 billion through 2046), to identify where the greatest uncertainties exist, and where investments in S&T can provide the maximum benefit. The assessment identified and described the eleven *strategic closure challenges* associated with the cleanup of the Hanford Site (see Table I).

Table I. Listing of Hanford Strategic S&T Challenges and Opportunities

S&T Challenges	S&T Opportunities
1. Retrieval of Remote-Handled Waste 2. RH-TRU Handling and Disposition 3. Highly Contaminated Facilities Deactivation 4. Nuclear Materials Management 5. Groundwater/Vadose Zone Phenomenology 6. Groundwater Remediation 7. Subsurface Soil Access 8. Surface Barrier Implementation 9. Canyon Disposition 10. Final Reactor Disposition 11. Integration with ORP	**1. RH Waste Retrieval and Disposition** **2. Groundwater and Subsurface Technologies** **3. Surface Barrier Development and Performance Monitoring** **4. Massive Facility Disposition Options Development**

Each of the challenges provides a strong driver and opportunity for S&T development to advance the Hanford 2012 Vision. Near-term S&T investments are needed to resolve both near-term issues and long-term closure objectives. However, there is insufficient funding to develop every available technology option or scientific research endeavor. Therefore, this assessment was

prepared to serve as a strategy to help RL focus its financial resources on four *fundamental S&T opportunities* that will provide the most significant schedule, cost, and safety impacts in the overall cleanup effort. By focusing on a limited number of critical, high-payback activities, alternatives to current baseline technologies can be developed for those very high risk and/or high cost problems.

The assessment was completed in the spring of 2001 and provided to DOE-HQ and the Hanford Site Technology Coordination Group (STCG) for review and input. It is the first step in developing a Site-level S&T strategy for RL. To realize the full benefits of this assessment, RL and Site contractors will work with the Hanford STCG to ensure:

- identified challenges and opportunities are reflected in project baselines
- detailed S&T program-level road maps reflecting both near- and long-term investments are prepared using this assessment as a starting point
- integrated S&T priorities are incorporated into Environmental Management (EM) Focus Areas, Environmental Management Science Program (EMSP) and other research and development (R&D) programs to meet near-term and longer-range challenges.

Hanford is now poised to begin the detailed planning and road mapping necessary to ensure that the integrated Site level S&T priorities are incorporated into the national DOE S&T program and formally incorporated into the relevant project baselines. DOE-HQ's response to this effort has been very positive and similar efforts are likely to be undertaken at other sites. Hanford was the first site where such a unique, comprehensive assessment was performed. This paper provides a means to share this approach with other sites and to introduce Hanford's S&T challenges to potential technology providers and other interested parties.

INTRODUCTION

Over the past year, RL has formulated a focused, outcomes-based vision for accelerated cleanup of the Hanford Site: "Hanford 2012: Accelerating Cleanup and Shrinking the Site" (2). The primary elements of this vision are to accelerate restoration of the Columbia River Corridor and transition the Central Plateau to long-term waste management, thereby shrinking the footprint of active site cleanup. Ultimate success of cleanup in the Hanford 2012 Vision and the difficult work scope beyond FY 2012 requires vigorous and sustained efforts to enhance the S&T basis of the cleanup, develop and deploy innovative solutions, and provide firm scientific bases to support site cleanup and closure decisions at Hanford.

The Hanford Site is a large and geographically diverse land area (1450 square kilometers) in southeastern Washington State (see Fig. 1). The Site is crossed by the last free-flowing stretch of the Columbia River and contains large areas of pristine shrub steppe habitat. While DOE maintains primary responsibility for the Hanford Site, portions of the Site (the Wahluke Slope and the Fitzner-Eberhardt Arid Lands Ecology Reserve) are under the jurisdiction of the U.S. Fish and Wildlife Service.

Plutonium production activities at Hanford between 1942 and 1988 left a legacy estimated at over 400 million curies of radioactive wastes and materials, 300,000 tons of chemical wastes,

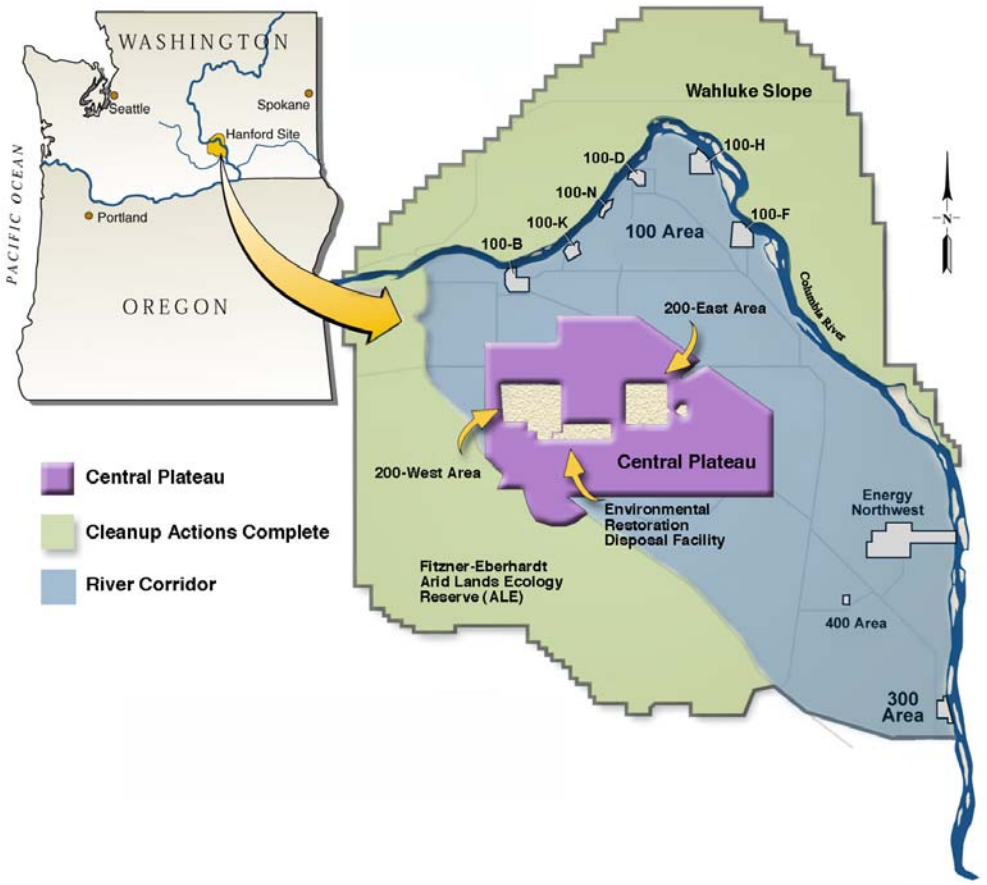

Fig. 1. Geographic Location and Principal Areas of the Hanford Site

and hundreds of contaminated facilities. Wastes were introduced into the ground and contaminated the vadose zone (the soil above the groundwater), the groundwater, and the Columbia River. According to the Hanford Comprehensive Land Use Plan Environmental Impact Statement (3), about 4 percent of the Site is surface-contaminated and 30 percent of the Site overlays groundwater contaminated from the past production of nuclear materials. The Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERLCA) National Priorities List (NPL) includes Hanford as a contaminated site requiring cleanup actions.

The sheer expanse of the Hanford Site, the inherent hazards associated with the significant inventory of nuclear materials and wastes, the large number of aging contaminated facilities, the diverse nature and extent of environmental contamination, and the proximity to the Columbia River make the Hanford Site arguably the world's largest and most complex environmental cleanup project. It is not possible to address the more complex elements of this enormous challenge in a cost-effective manner without strategic investments in S&T. An integrated technology program is an essential element of the overall cleanup effort and is needed to provide both step improvements and breakthrough opportunities for accomplishing the cleanup within reasonable costs and schedules.

The Hanford Site is home to two operations offices for DOE. The missions of these offices are as follows:

1. **RL Operations Office** – manages the non-tank waste portion of the Hanford's Environmental Management (EM) mission. RL also manages Hanford's Science and Technology mission (including management of the Pacific Northwest National Laboratory).
2. **Office of River Protection** – manages the tank waste portion of Hanford's EM mission.

Assessment Scope and Purpose

The purpose of the assessment is to provide a single, strategic perspective on RL Site closure challenges and associated S&T opportunities that:

- supports planning and implementation of the Hanford 2012 Vision and beyond
- identifies possible breakthrough opportunities for very high risk and/or high cost problems
- ensures S&T opportunities are linked to and driven by outcomes consistent with revised project baselines and Hanford 2012 Vision
- identifies where S&T opportunities are tied to key site cleanup decisions
- is consistent with the outcome-based contracting strategy for the Site
- considers both near-term and long-range cleanup challenges.

It is generally understood that new technologies and scientific research are needed to successfully clean up the Hanford Site and support closure decisions. The *baseline* plan for RL's portion of the EM mission has been developed to guide the Hanford cleanup process at an estimated cost of approximately $24 billion in constant FY 2000 dollars through FY 2046. The baseline plan is founded on a broad range of enabling assumptions concerning the application of technologies for various cleanup elements. In some cases, work can proceed as planned, although enhanced technologies could increase the efficiency with which the work is performed, thereby freeing funds for additional cleanup. In other cases, uncertainty in site conditions and hazards, as well as uncertainty in the ability of baseline technologies to achieve the cleanup objectives, suggest a need for better understanding and the potential for dramatically different approaches.

Hanford must have a balanced S&T program that promotes the development of near-term tools and technologies. The program must enhance our confidence in meeting immediate cleanup goals within anticipated budgets. The program must also invest in the long-term technology and scientific understanding needed to achieve final cleanup end states. The cleanup objectives in the out-years present some of the biggest opportunities for savings and greatest potential for reducing uncertainties. Enabling continued progress on these objectives to realize the potential long-term dividends will require an investment in S&T now.

This strategic assessment covers all life-cycle elements of RL's cleanup mission consistent with both the near-term goals of the Hanford 2012 Vision as well as the longer-range final closure objectives. While this assessment deals specifically with the RL scope of work, common

challenges faced by DOE's Office of River Protection (ORP) were identified. RL and ORP are committed to working together to solve common Hanford Site challenges affecting both operations offices.

Assessment Process

To date, formulation and development of S&T needs within DOE-EM has logically focused on a subset of the Site's life-cycle needs. Since 1994, DOE-EM has organized S&T development around the EM Focus Areas that interact with the Hanford Site STCG to identify S&T needs and develop technologies to serve cleanup at the Site. Because only a few years (typically 3 to 5) of project work are planned in detail at any time, and because identifying S&T needs favors content that is user supported for near-term deployment, there is bias built into this process against addressing fundamentally difficult, long-term problems. To address this issue, this assessment identified and described the eleven *strategic closure challenges* associated with the cleanup of the Hanford Site.

The methodology for identifying strategic closure challenges and associated S&T opportunities, and the relationship of this assessment to ongoing Hanford S&T needs identification process through the STCG, is illustrated on the process flow diagram in Fig. 2.

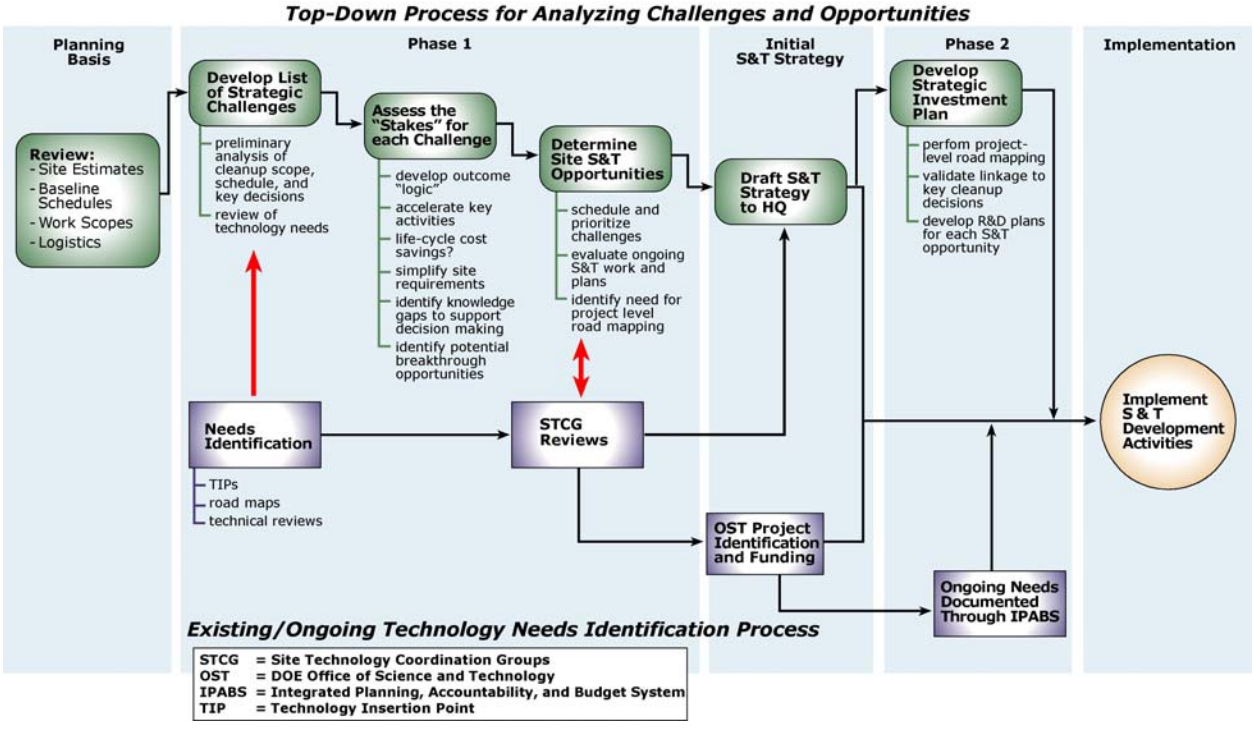

Fig. 2. Hanford Site Integrated Science and Technology Process

The criteria used to identify strategic closure challenges are listed below:

- Challenges require large investments or long time frames to complete.
- Confidence in achieving the desired outcomes for the challenge is low or very uncertain.

- Feasibility of desired endpoints or end states is still uncertain or undefined.
- Breakthrough opportunities are possible by simplifying requirements, accelerating schedules, or improving efficiencies.

HANFORD SITE SCIENCE AND TECHNOLOGY CHALLENGES

The primary focus of this assessment was to identify Hanford's strategic closure challenges. The strategic closure challenges were identified and refined through a series of workshops with participants from the planning and project organizations within RL, ORP, Site Contractors, and the Pacific Northwest National Laboratory (PNNL). Strategic input was also provided from the regulators (EPA and Washington State Department of Ecology). Because of the crosscutting nature of this assessment, it could only have been assembled with insight and strong support from all the participants. The identified closure challenges are introduced below in Table II and briefly discussed on the following pages.

Table II. Hanford Site Strategic Closure Challenges[a]

Challenge	Scope	Issues
Retrieval of Remote-Handled Waste	Includes numerous buried waste sources and sites with high dose-rate materials such as the 618-10/11 burial grounds, 200 Area caissons, and other potential sites.	Work has large technical uncertainties, is labor and dose intensive, has environmental control issues, and is very costly.
RH-TRU Handling and Disposition	Treatment and disposition of RH-TRU wastes from contaminated facilities, burial grounds, and underground caissons. Includes operation of new and/or modification to existing waste management facilities.	Work is labor intensive, has high degree of uncertainty, presents potential worker protection issues, and is very costly, both in terms of operation and construction of new capabilities.
Highly Contaminated Facilities Deactivation and Decommissioning	Deactivation/decommissioning of 200 and 300 Area process and laboratory facilities with high levels of contamination.	Work is labor and dose intensive, presents potential worker protection issues, is very costly, and in many cases has large uncertainties.
Nuclear Material Management	Includes all aspects of material management of SNF, cesium and strontium capsules, and plutonium and plutonium residues.	Very high base operations costs (high potential returns for accelerating schedules) for stabilization (where needed), safe storage, and offsite disposal.
Groundwater/ Vadose Zone Phenomenology	Crosscutting activity to enhance understanding of contamination sources, vadose zone, groundwater, and river interactions.	Common basis of understanding and data for remedial action decisions along with S&T road map for remediation.
Groundwater Remediation	Applicable to all chemical and radioactive groundwater contamination plumes.	Existing interim action technologies are inadequate to meet cleanup standards necessary for final remediation.
Subsurface Soil Access	Crosscutting applications for difficult-to-access contamination in deep subsurface sites under buildings or other structures.	High costs and technical drivers for investigations, monitoring, and remediation of the deep vadose zone and groundwater all require better access.
Surface Barrier Implementation	Applicable primarily to 200 Area closures (burial grounds, canyons, structures, and other soil contamination sites).	The high costs projected for surface barriers, environmental impacts of obtaining raw materials, and long-term surveillance and maintenance costs are all issues.
Canyon Disposition	Applicable to all 200 Area canyon facilities disposition.	Large potential savings as consolidated waste facilities. Challenge will be the acceptance of the existing structure and systems as a compliant storage/disposal facility.

Table II. (contd)

Challenge	Scope	Issues
Final Reactor Disposition	Applicable to all production reactors in Interim Safe Storage (ISS). Potentially applicable to FFTF.	Work is labor intensive, has high degree of uncertainty, presents potential worker protection issues, and is very costly.
Integration with ORP	Final closure and remediation of waste tanks and surrounding areas have challenges similar to those described above.	Common areas of concern include characterization, equipment size reduction, treatment and packaging, groundwater/vadose zone interaction, and barrier performance.

[a] Implicit in resolving these specific challenges is the crosscutting need to enhance worker protection tools necessary to safely accomplish these difficult tasks.

Retrieval of Remote-Handled Waste

While the Hanford 2012 Vision does not include retrieval of buried wastes at the 618-10/11 waste disposal sites (those are targeted to be cleaned up after FY 2013), remediation of these and other high-activity waste burial sites poses significant technical challenges and risks. Tri-Party Agreement (TPA) milestone M-16-00 requires remediation of these sites to be completed by FY 2018. Stakeholders and regulators (4) have indicated that advances in the retrieval of RH waste are a high priority. In addition, the ability to characterize and process these wastes could substantially affect the safety and cost-effectiveness of these projects in achieving cleanup objectives. The technology-driven path forward has not been determined for characterizing and retrieving wastes from these sites safely at this time, making it a primary and real-time S&T need.

Remote-Handled Transuranic (RH-TRU) Waste Handling and Disposition

RH-TRU and other high-activity wastes retrieved from Hanford burial grounds and removed from contaminated facilities require processing for disposition, including characterization, segregation, size reduction, and packaging. Development of innovative technologies to address these requirements, either in the field at waste retrieval or facility deactivation sites or at a central 200 Area location, is a key near-term S&T opportunity to support achievement of Hanford cleanup objectives. Technology for size reduction of large contaminated objects has been identified as a particularly pressing S&T need in this area.

Highly Contaminated Facilities Deactivation and Decommissioning

Accelerated facility deactivation and decommissioning of highly contaminated facilities present significant technical challenges and potential S&T opportunities. Innovative technologies are needed for in-place characterization of contaminated equipment. In addition, development of improved portable/modular and central size reduction and waste processing systems would significantly enhance the safety, efficiency, and cost performance of the facility disposition mission if addressed early in project planning and execution. Safe and cost-effective tools and systems for characterization, decontamination and fixation of contaminants and dismantling and/or removal, size reduction, packaging and disposition of contaminated components are key S&T needs in this area.

Nuclear Materials Management

Substantial work will be required to transition the Central Plateau to support the Site’s longer-term waste management mission. Part of that transition is stabilizing and storing nuclear materials, including SNF, plutonium, and cesium and strontium capsules. Due to the inherent hazards these materials present and the age of some of these facilities, significant resources are required for safe storage. The sooner these materials can be stabilized and shipped offsite for final disposition, the greater the potential savings. This cost incentive challenges DOE to streamline the materials management mission, thus speeding up the process and freeing up some of that funding for cleanup. Possible opportunities include modifications to the Spent Nuclear Fuel Project to change the configuration of storage canisters and modifications to plutonium stabilization and storage processes. Enhanced technologies (based on these key S&T needs) may be identified in these areas that could 1) lead to improvements in shortening the schedule for moving the fuel away from the Columbia River and 2) lower plutonium processing and storage costs.

Groundwater/Vadose Zone Phenomenology

The Groundwater/Vadose Zone (GW/VZ) Integration Program now in place at Hanford (5) is structured to provide the necessary scientific basis for understanding long-term risks and to develop and assess alternative remedial actions. However, there remain significant challenges to enhance knowledge of GW/VZ contamination and to improve GW/VZ phenomenological models that support development and validation of surface barriers and other remedial technologies and support both near-term and long-range cleanup decisions. Completion of the groundwater remediation road map (linking S&T research and development activities to the Site baseline as driven by TPA milestones) is a key S&T need that supports the urgent groundwater remediation challenge discussed below. The GW/VZ Integration Program must focus on, and be driven by, the pressing S&T needs associated with soils and groundwater remediation decisions.

Groundwater Remediation

The eventual replacement of interim groundwater remediation projects now ongoing in the River Corridor and Central Plateau is required under the applicable groundwater remediation RODs. No remediation technology exists to meet this requirement for all the groundwater contamination plumes. Indefinite operation of the existing pump and treat systems adds costs to the program with only limited benefits. Current baseline plans call for implementation of enhanced remedies midway through this decade. Developing innovative groundwater remediation technologies and solutions, therefore, represents a major cleanup challenge and a key S&T need for the Site. This challenge is urgent. Stakeholders (4) and regulators (6) have both expressed that advances in groundwater remediation are urgently needed.

Subsurface Soil Access

Development of improved capabilities for accessing deep soils and groundwater would enable application of innovative in situ characterization, monitoring, and remediation technologies.

Enhanced subsurface access is a key S&T need for in situ characterization and monitoring that support surface barrier development, GW/VZ integration S&T efforts, and groundwater and deep soil remediation options.

Surface Barrier Implementation

In addition to the near-term challenges and S&T opportunities arising from the Hanford 2012 Vision, additional challenges and opportunities arise from long-range Site closure objectives that extend out to FY 2046. For instance, surface barriers are a primary requirement to enable final in situ disposal of wastes on the Central Plateau (7). The need to refine and optimize surface barrier design and validate performance in a timely manner is therefore a strategic S&T need for supporting key cleanup decisions and ultimate site closure and long-term stewardship requirements.

Canyon Disposition

The key challenge of the 200 Area chemical processing canyons is to establish a final approach for disposition of the canyon structures and the wide spectrum of wastes they contain to achieve final closure of the sites. Disposition options range from cleanout, demolition, and removal to entombment in place, possibly serving as disposal sites for other Hanford wastes. The key S&T needs for the canyon disposition challenge are: 1) evaluation and screening of technologies in support of selection of the preferred disposition option (including both waste placement and facility decommissioning needs) and 2) development of technologies needed to implement the preferred disposition option.

Final Reactor Disposition

The Environmental Impact Study (EIS) record of decision (ROD) pertaining to final reactor disposition requires that after the interim safe storage (ISS) period the reactors will be transported intact to the Central Plateau for disposal. However, TPA negotiations between RL and the regulators have established a TPA milestone (M-93-12) that requires this decision to be revisited in FY 2002 to determine whether technology has evolved sufficiently to require that other options and requirements be considered. This evaluation will examine removal techniques and timing for disposition, including potentially accelerating final disposition of the reactor building. Accelerating final disposition would replace the safe storage enclosure part of the reactor ISS action (i.e., new roof and monitoring system for long-term surveillance and maintenance). An incentive for additional S&T investment is that the prospect of simplifying the disposal process for the reactor blocks could lead to reduced worker risk and fewer environmental impacts. Therefore, the key S&T needs for the reactor disposition challenge are evaluation and future development of technologies in support of the selected disposition option.

Integration with ORP

RL and ORP will continue to work together to solve challenges that are common to both operations offices. These include tank farm closure challenges related to soils characterization, GW/VZ interaction, barrier development, removal and processing of RH-contaminated

equipment and wastes, and deactivation of highly contaminated facilities. Final closure of the tank farms presents unique challenges, but many of these challenges share S&T needs similar to those facing RL. Resolution of these key S&T needs should be integrated to maximize the benefits to both operations offices.

ANALYSIS OF THE S&T OPPORTUNITIES

The objective of the assessment was to develop a Site-level S&T strategy by identifying S&T opportunities where additional investments could reduce time, cost, and/or risks. This assessment is intended to complement the existing STCG process (which addresses important and urgent needs and solutions that affect near-term baseline performance) by identifying strategic life-cycle challenges in the site cleanup baseline for which there currently are no readily available solutions, where existing solutions have proven to be ineffective, or where existing solutions are prohibitively expensive or pose significant health and safety risks.

The analysis of these challenges has led to a broad understanding that advances in S&T could have a positive effect on several significant portions of the baseline plan. Some of these challenges involve hundreds of millions of dollars in baseline scope and are fundamental for successfully achieving the Hanford 2012 Vision and beyond. Fig. 3 provides a high-level

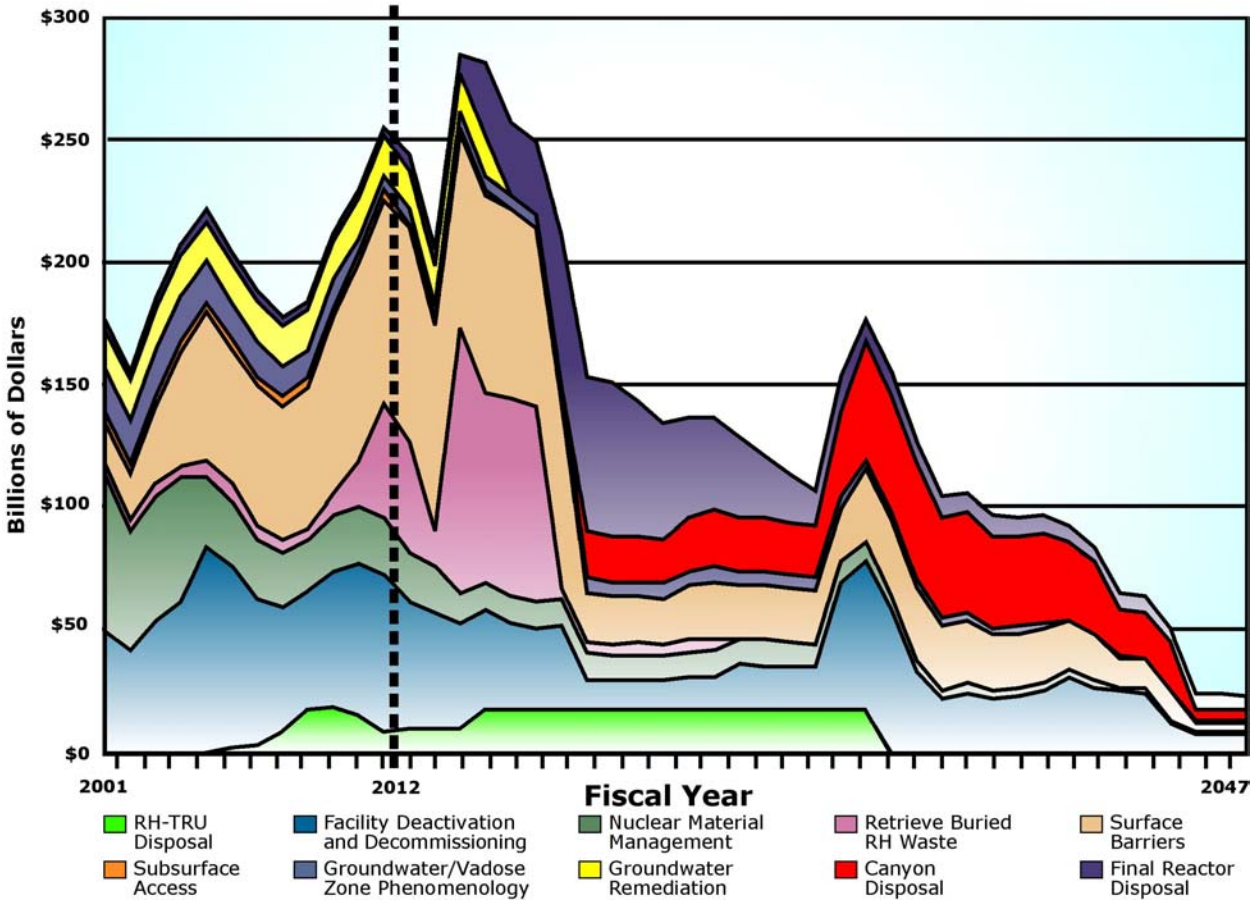

Fig. 3. Aggregated Cost of Associated Baseline Scope by Site Closure Challenges

analysis of the planned funding profile for baseline activities associated with each challenge. The data were derived through a parametric assessment of the overall scope within major site baseline elements. Only those portions of the baseline deemed relevant to each challenge were selected. This analysis assesses the funding levels and timing for each challenge. However, the costs presented on these curves are taken from the existing site baseline and, as discussed in the challenge descriptions, are based on a broad range of assumptions and contain varying levels of uncertainty. It would not be appropriate to use these data as sole discriminators for determining site S&T priorities. However, for providing an early assessment of S&T opportunities with potentially large paybacks, this approach is useful.

Fig. 4 illustrates the Hanford Site strategic challenges in relation to the time frame needed for their resolution. The figure also provides a conceptual depiction of where each of the challenges lies on the research and development spectrum. The time frame shown for each challenge provides a general indication of when technology insertion must be made to allow project execution to proceed as planned. S&T development activities must be conducted prior to these time frames. This simple illustration provides important information with respect to both the urgency of each challenge and to the form of the anticipated S&T efforts that might be required to resolve the challenge. This figure also provides a means for relating some of the needs that are common to many of the challenges, such as characterization of high dose rate materials, size reduction of contaminated components, and subsurface access.

FUNDAMENTAL SCIENCE AND TECHNOLOGY OPPORTUNITIES

RL strongly believes that S&T investments in these areas are needed and will support the DOE Office of Science and Technology (OST) in defending funding requests to meet these challenges during programmatic reviews. Each of the challenges provides a strong driver and opportunity for S&T development to advance the Hanford 2012 Vision and eventual site closure. Near-term S&T investments are needed to resolve both near-term issues and long-term closure objectives to enhance the credibility of the technical baselines by identifying opportunities to reduce the expected costs, potentially accelerating scheduled completion, and reducing programmatic uncertainties associated with the cleanup activities. However, there is insufficient funding to develop every available technology option or scientific research endeavor. Therefore, this document serves as a strategy to help RL focus its financial resources on *fundamental S&T opportunities* that will provide the most significant schedule, cost, and safety impacts in the overall cleanup effort.

As an organizing concept, an "S&T Opportunity" is a set of one or more challenges that satisfy any of the following additional criteria:

- There is a reasonable prospect for successful resolution of the technical issue(s) in a sufficiently complete and timely manner at reasonable cost.
- The same or similar technical issue(s) in different projects or challenges may be combined to frame problems in a fundamental, generic manner, addressing multiple needs.
- The potential solutions satisfy a previously unresolved need to reduce risk and further cleanup objectives.

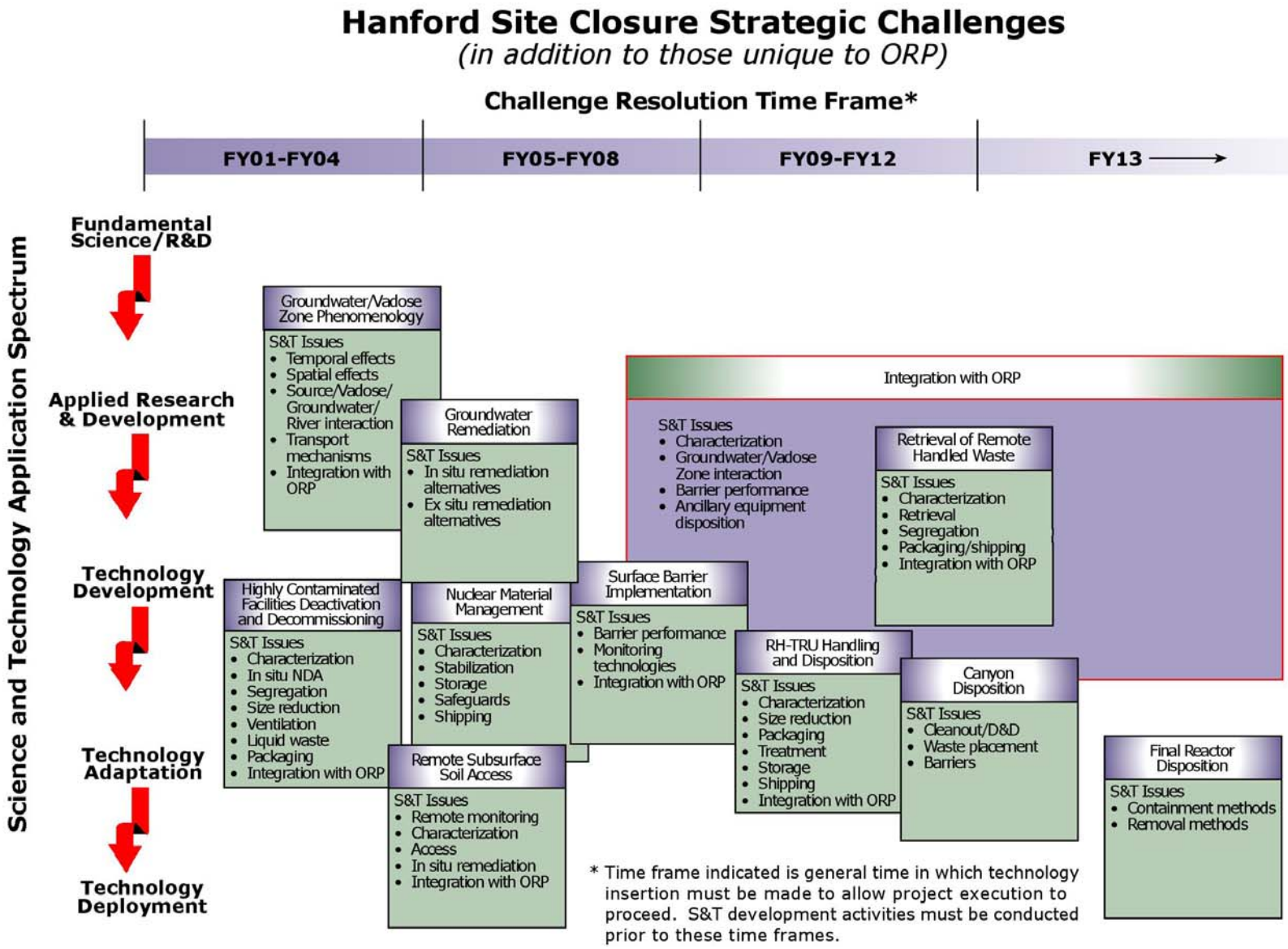

Fig. 4. Hanford Site Closure Strategic Challenges

Four fundamental S&T opportunity areas have been initially identified. Two of these—RH Waste Retrieval and Disposition and Groundwater and Subsurface Technology Development—were identified as high-priority items by the Hanford Advisory Board (HAB) in Consensus Advice #113, which was provided on December 8, 2000 (4). Each of the proposed fundamental S&T opportunity areas is described briefly below.

RH Waste Retrieval and Disposition

Significant challenges exist, both at Hanford and at other DOE sites, for dealing with RH waste. A number of the Site closure challenges have key needs in the characterization, designation, retrieval, segregation, size reduction, packaging, transportation, processing, and disposition of RH waste. The processing and disposition of these RH waste streams will require close coordination with the development of the M-91 processing facilities and, potentially, the Canyon Disposition Initiative (CDI).

A technology development program is needed that is aimed specifically at supporting these needs with a strong emphasis on waste retrieval and supporting actions for the buried RH wastes at 618-10 and 618-11 burial grounds within the River Corridor. This opportunity area should also focus on developing innovative characterization/designation techniques for high dose-rate TRU waste (including meeting RH-TRU certification requirements for the waste isolation pilot project). In addition to the 618-10 and 618-11 burial grounds, the development in this area will also support retrieval of the caissons in the 200 Area and removal of remote-handled equipment associated with the tank farms.

Focusing on retrieval and disposition of high dose-rate wastes as an opportunity will help to ensure that the systems and facilities needed for dealing with these problematic wastes are well conceived and are designed to support the range of challenges Hanford must face. This opportunity area would also support similar challenges facing the deactivation and decommissioning of highly contaminated facilities. A number of highly contaminated facilities with glove boxes, hot cells, chemical process cells, and other contaminated components are now at the end of their operational life and must undergo deactivation and decommissioning. These facilities have large inventories of radioactive materials and high levels of contamination. To safely and cost-effectively clean up and decommission these facilities, advanced technologies and approaches are required.

Technologies needed to deactivate and decommission such facilities and retrieve buried RH wastes include remote access, size reduction, and packaging of highly contaminated equipment and materials (glove boxes, hot cells, piping, ducts, large equipment, buried wastes, caissons, etc.). S&T is also needed to develop and improve capabilities for dismantlement and decommissioning of large contaminated structures. By considering these challenges together, possible solutions could be realized, such as the development of modular containment and ventilation systems, portable decontamination systems, centralized size reduction and waste processing facilities, streamlined waste handling and shipping processes, shared use of robust cutting systems, and improvements in worker training and execution.

Concepts in alternative ventilation options and enhanced worker monitoring and protection tools will need to be explored to protect the workforce during both the buried waste retrieval and facility deactivation and decommissioning operations. Liquid waste handling and transportation will also be important elements. Waste classification and segregation should be addressed within this opportunity area to minimize waste generation and reduce overall costs.

An S&T opportunity area for RH waste should also be closely tied to the “Management of Nuclear Materials” challenge (e.g., spent nuclear fuel and plutonium bearing materials). The near-term S&T needs to optimize stabilization processes, packaging techniques, transportation approaches, and storage methods could be of direct benefit to similar functions that will be required for RH wastes. When the RH waste retrieval and disposition opportunity area is more fully developed, both the RH waste and nuclear material challenges should be addressed in the overall context of satisfying needs to handle and disposition wastes and nuclear materials that are inherently dangerous.

Groundwater and Subsurface Technology

The Hanford Site has widespread vadose zone and groundwater contamination plumes. A number of interim actions are under way that involves groundwater pump-and-treat systems. However, current plans are to run these systems for only a limited time until a more effective and permanent remedy can be selected and implemented. The baseline assumes that a cost-effective technology will be available for remediating groundwater. The current long-range plan calls for decisions for enhancing groundwater remediation approaches to be made by the start of FY 2007. Without S&T activities leading to alternative remediation technologies, this schedule will not be met. The consequence of a failure to meet this schedule is that baseline groundwater remediation would continue well past FY 2015 until alternative actions have been identified and implemented. Thus, additional costs will be incurred without early identification and deployment of new groundwater technologies.

The GW/VZ Integration Project is well under way, and the S&T component is providing data and models to support Site-specific and Site-wide remediation decisions. The GW/VZ Integration Project is focused on decisions regarding interim corrective actions for tank farms where tank leaks have impacted groundwater and soil waste site characterization. Other areas of focus for this project (inventory, groundwater-river interface, and ecological risk) are providing data and conceptual models for Site-wide assessments. A primary recommendation for this opportunity area is that the S&T road map to address remediation of soil and groundwater contamination be developed as soon as possible so that scientific research and technology development activities can be focused on addressing remediation options.

This opportunity area must be closely aligned with the surface barrier and testing opportunity area as well as with the S&T process being used by ORP to identify important issues that need to be addressed. ORP issues related to this challenge area will be focused on the vadose zone beneath the tank farms and the impacts from past leaks as well as potential future impacts from retrieval operations.

Surface Barrier Development and Performance Monitoring

A surface barrier program, including the full-scale treatability testing of a modified RCRA Subtitle C barrier, is needed to provide performance data and development of more robust, long-lived, cost-effective monitoring technologies. Cost-effective and proven barrier designs that are acceptable to the regulators are needed to satisfy elements of a number of the challenge areas and are crucial for safe long-term isolation of waste sites on the Central Plateau.

A seven-year comprehensive treatability study is planned as part of the 200 Area Remedial Action Project to test a full-scale modified RCRA Subtitle C barrier. Acceleration and focusing of these activities are needed to ensure that the key cleanup RODs can be supported in a timely manner and that barrier designs can be optimized to minimize costs and environmental impacts. In addition, development of improved monitoring techniques and robust designs will factor directly into the scope of post-closure stewardship actions that are required following installation of these barriers over waste sites.

Massive Facility Disposition Options Development

A focused S&T effort is needed to support the selection of disposition pathways for the canyons and reactor blocks. For the canyons, the principal alternatives range from cleanout, dismantlement, demolition, and removal (in part or in whole) for disposal to various options involving conversion of the canyons for use as in-place waste disposal facilities. For the reactor disposition challenge, an evaluation of alternative disposition pathways for the reactor blocks is planned for FY 2002. In particular, S&T activities are needed to support evaluation of alternatives to the baseline approach selected in the 1989 reactor disposition EIS ROD, which requires moving the intact reactor blocks to the Central Plateau for disposal. Principal alternatives for disposition of the reactor blocks include various combinations of dismantlement, demolition, and removal (in part or in whole) to the Central Plateau for disposal.

The common ground of these two challenges is, therefore, the need to evaluate approaches and technologies for large equipment size reduction, remote handling and dismantlement of structures, and waste packaging and transportation options, as well as for barriers and for monitoring of wastes disposed in-place. This S&T opportunity area should include detailed S&T road-mapping activities as well as Site-level systems studies to evaluate approaches to make the most efficient use of the canyons as disposal facilities.

CONCLUSIONS AND RECOMMENDATIONS

The long-term success of Hanford cleanup requires vigorous and sustained efforts to enhance the S&T basis of the cleanup, develop and deploy innovative solutions, and provide firm scientific bases for decisions that address cleaning up the nuclear waste legacy at the Site. The results of this S&T assessment highlight strategic closure challenges in the Hanford cleanup baseline for which available solutions are inadequate and which therefore offer significant S&T opportunities to advance the Hanford 2012 Vision. Full integration of these strategic closure challenges into RL’s S&T research and development processes will ensure that investments made will result in

the maximum benefits across the Hanford Site and are fully supportive of the Hanford 2012 Vision. The complete S&T assessment (1) is available electronically on the Hanford Site STCG Web site at http://www.hanford.gov/boards/steg/pdfs/documents/2238aall.pdf

Specific Conclusions

Although high level, this assessment was sufficiently complete to substantiate several significant and urgent S&T priorities. These activities (identified in terms of fundamental S&T opportunities) should be addressed in an expeditious manner.

- **RH Waste Retrieval and Disposition**: Initiate an integrated effort to identify and develop technologies for the retrieval and disposition of remote-handled wastes and nuclear materials. A program-level road-mapping process should be undertaken to identify specific technology gaps and the S&T activities needed. This effort should focus on a cross-project assessment of the systems needed for size reduction, processing, packaging, transportation, and storage of RH wastes and nuclear materials and should also include an emphasis on the S&T required for retrieval of buried RH wastes at the 618-10 and -11 burial grounds. The possibility exists to coordinate this roadmapping effort on a national level to ensure consistency in approach for other sites with similar needs. On this basis, initiate an S&T effort to develop, test, validate, and deploy the selected technologies.

- **Groundwater and Subsurface Technology**: Focus on developing, demonstrating, and deploying groundwater and deep soil remediation technologies and tools, including innovative access technologies. The first step in this process will be to complete the remediation S&T road map to identify an overall approach and S&T activities needed to develop appropriate soil and groundwater remediation technologies and tools. Expand the knowledge of S&T needs for groundwater and deep soil remediation and initiate the S&T activities necessary to develop, validate, and deploy the selected remedial technologies and tools.

- **Surface Barrier Development and Performance Monitoring**: Initiate full-scale surface barrier testing and performance monitoring to optimize and validate alternative barrier designs for long-term application at Hanford waste sites and engineered disposal facilities.

- **Massive Facility Disposition Options Development**: Support reactor block and canyon disposition key decisions required in FY 2002; identify, plan, and conduct more detailed S&T road-mapping following selection of the preferred disposition paths.

Path Forward

To implement this strategy, detailed program-level road maps will be developed in the next phase of S&T planning to identify specific S&T activities and potential breakthrough opportunities, provide linkage to outcomes consistent with revised project baselines, and establish ties to key site cleanup decisions. The road maps could be site specific or have a

regional or national focus if determined to be advantageous. Detailed definition of the depth and breadth of the fundamental S&T opportunities and the relative priority and urgency of each will be a natural product of this follow-on activity.

Full integration of the strategic closure challenges into RL's research and development processes will ensure investments made result in the maximum benefits across the Hanford Site and are fully supportive of the Hanford 2012 Vision and eventual site closure. This assessment will serve to focus and identify the challenges and issues Hanford believes the DOE OST Program can support in meeting its cleanup objectives. RL will work closely with OST to justify DOE-EM budgets that will address Hanford's unique challenges and S&T opportunities.

This assessment is the first step in developing an integrated Site level S&T strategy for RL and does not yet address how to structure and implement future S&T efforts. To realize the full benefits of this assessment, RL and Site contractors will work with the Hanford STCG to ensure that:

- identified challenges and opportunities are reflected in project baselines and contractor developed, project-level S&T plans addressing the near-term challenges
- detailed program-level S&T road maps reflecting both near- and long-term investments are prepared using this assessment as a starting point
- integrated S&T priorities are incorporated into EM Focus Areas, EMSP and other R&D programs to meet near-term and longer-range challenges
- this assessment is periodically revisited to reflect new challenges and S&T opportunities as work scope is completed.

By focusing the advance of needed scientific information and technology applications on a limited number of critical, high-payback activities, it will be possible to further Hanford's cleanup objectives within reasonable costs and reasonable schedules. RL is working to ensure that an integrated S&T program is an essential element of its cleanup baseline. This program element must provide on-the-ground support to the cleanup effort leading to near-term step improvements as well as advances leading to longer-term, life-cycle breakthrough opportunities.

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